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RMA CONTAMINATION CLEANUP

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— COMMITTED TO PROTECTION OF THE ENVIRONMENT —

COMPREHENSIVE MONITORING PROGRAM

Contract Number DAAA15-87-0095

FINAL TECHNICAL PLAN

Version 3.2

JUNE 1989

GROUND WATER

Rocky Mountain Arsenal
Information Center
Commerce City, Colorado

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THE PURPOSE OF THE GROUND WATER ELEMENT OF THE COMPREHENSIVE MONITORING PROGRAM IS TO MONITOR GROUND WATER QUALITY AND WATER LEVELS.

THIS PROGRAM HAS THREE COMPONENTS:

1. REGIONAL PROGRAM MEASURES WELLS ON-POST AND OFF-POST ANNUALLY
2. SPECIFIC AREA PROGRAM MEASURES WATER LEVELS AND COLLECTS SAMPLES SEMI-ANNUALLY IN AREAS REQUIRING FURTHER DEFINITION OF MIGRATION PATTERNS
3. QUARTERLY PROGRAMS COLLECT SAMPLES IN AREAS REQUIRING DETAILED CHARACTERIZATION OF CONTAMINATION AND HYDROLOGIC CONDITIONS.

SECTIONS OF THIS PLAN PROVIDE INFORMATION ON THE FOLLOWING:

1. GROUND WATER PROGRAM INCLUDING NETWORK DESIGN RATIONALE, WELL SELECTION CRITERIA, LISTS OF WELLS, SAMPLING FREQUENCY
2. LABORATORY ANALYSIS
3. GEOTECHNICAL PROGRAM
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COMPREHENSIVE MONITORING PROGRAM

Contract Number DAAA15-87-0095

FINAL TECHNICAL PLAN

Version 3.2

JUNE 1989

GROUND WATER

Prepared by:

R. L. STOLLAR & ASSOCIATES INC.
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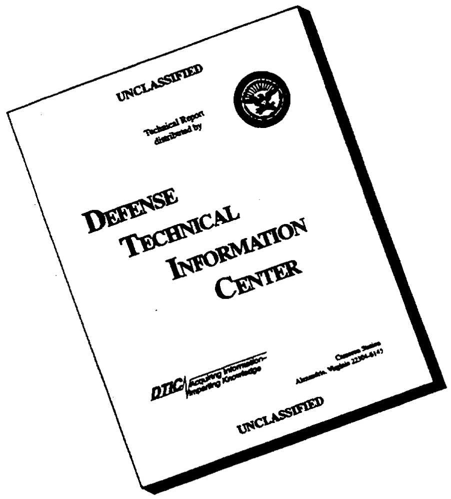

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1.0 INTRODUCTION

1.1 Site History

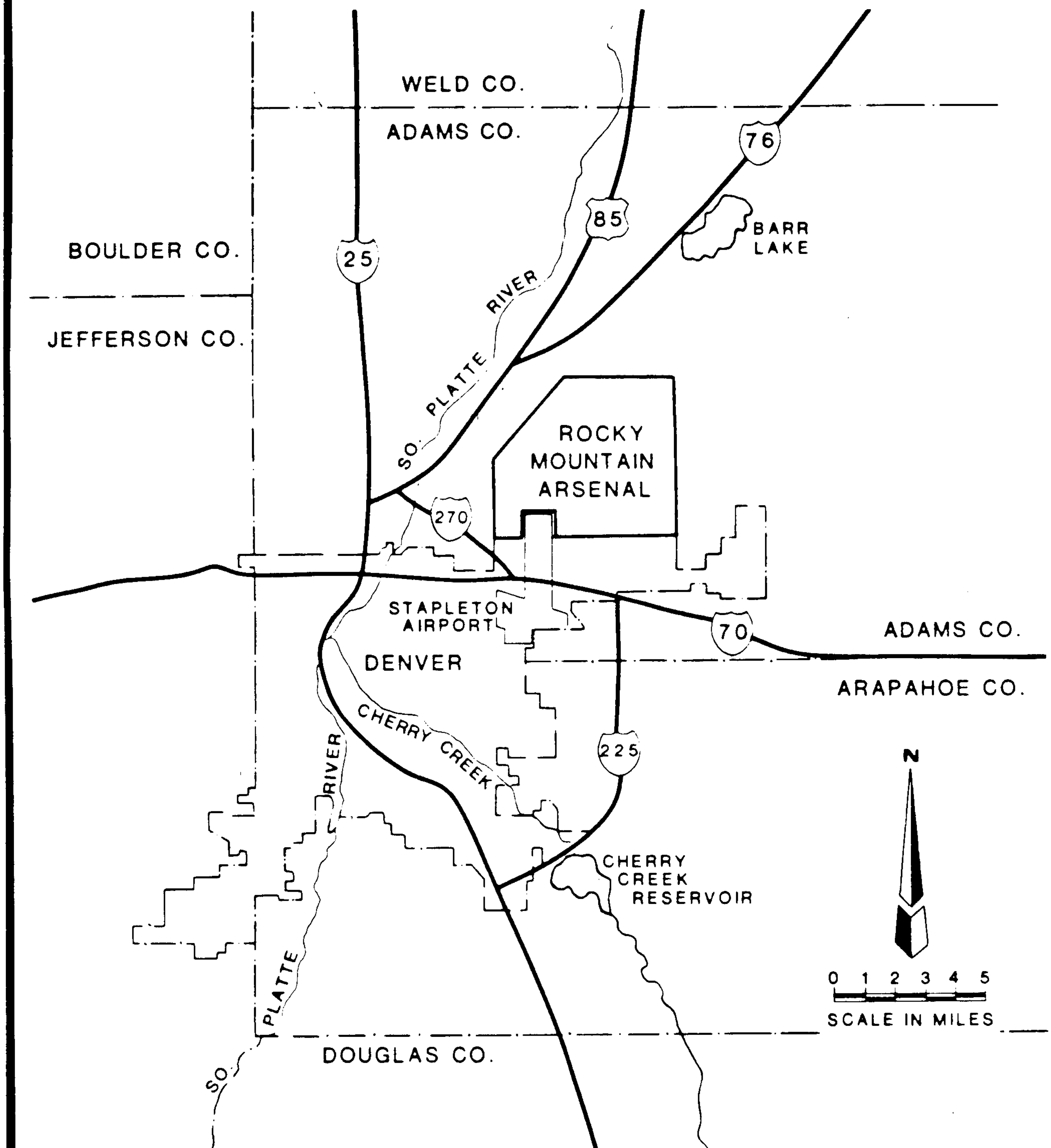
The Rocky Mountain Arsenal (RMA) occupies approximately 27 square miles (sq mi) in Adams County, Colorado, and is located 9 miles (mi) northeast of downtown Denver (Figure 1.1-1). RMA was established by the United States Army (Army) in 1942 for the production, handling, and demilitarization of chemical and incendiary munitions. In addition, industrial chemicals were manufactured at RMA by several lessees from 1947 to 1982.

From 1945 to 1950, RMA distilled stocks of Levinstein (H) mustard, demilitarized mustard-filled shells, and test-fired 107-millimeter (mm) mortar rounds filled with smoke and high explosives. Many different types of obsolete WWII ordnance were also destroyed by detonation or burning during that period.

In the early 1950s, RMA was selected to produce the chemical nerve agent Sarin (GB). The construction of the manufacturing facility was completed in 1953 and chemical agents were produced until 1957, with munitions filling operations continuing until late 1969. From 1970 until 1984, RMA had been involved primarily with the demilitarization of chemical warfare materials.

In 1947, portions of RMA were leased to the Colorado Fuel and Iron Corporation (CF&I) and the Julius Hyman and Company (Hyman) for chemical manufacturing. CF&I produced chlorine and fused caustic, chlorinated benzenes and attempted to manufacture dichlorodiphenyltrichloroethane (DDT). Hyman produced several pesticides. In 1950, Hyman added to its lease a number of facilities formerly operated by CF&I. In 1952, Shell Chemical Company (Shell) acquired Hyman and operated this company as a wholly owned subsidiary until 1954, when Hyman was integrated into the Shell corporate structure as the Denver Plant and Shell succeeded Hyman as the named lessee. From 1952 until 1982, Hyman/Shell produced a large number of herbicides and pesticides at RMA.

Disposal practices at RMA have included routine discharge of chemical waste effluents to unlined and lined evaporation basins and burial of solid wastes at various locations. In addition, unintentional spills of raw materials, process intermediates, and end products have occurred within the manufacturing complexes at RMA. Some of the compounds are readily mobile in surface and ground waters while others, such as pesticides, are more strongly attenuated by soil.



Source: RMA, 1983. ESE, 1987

Prepared for:

Program Manager's Office for
Rocky Mountain Arsenal Cleanup
Commerce City, Colorado

Drafted: 4/29/88

FIGURE 1.1-1

Rocky Mountain Arsenal
Location Map

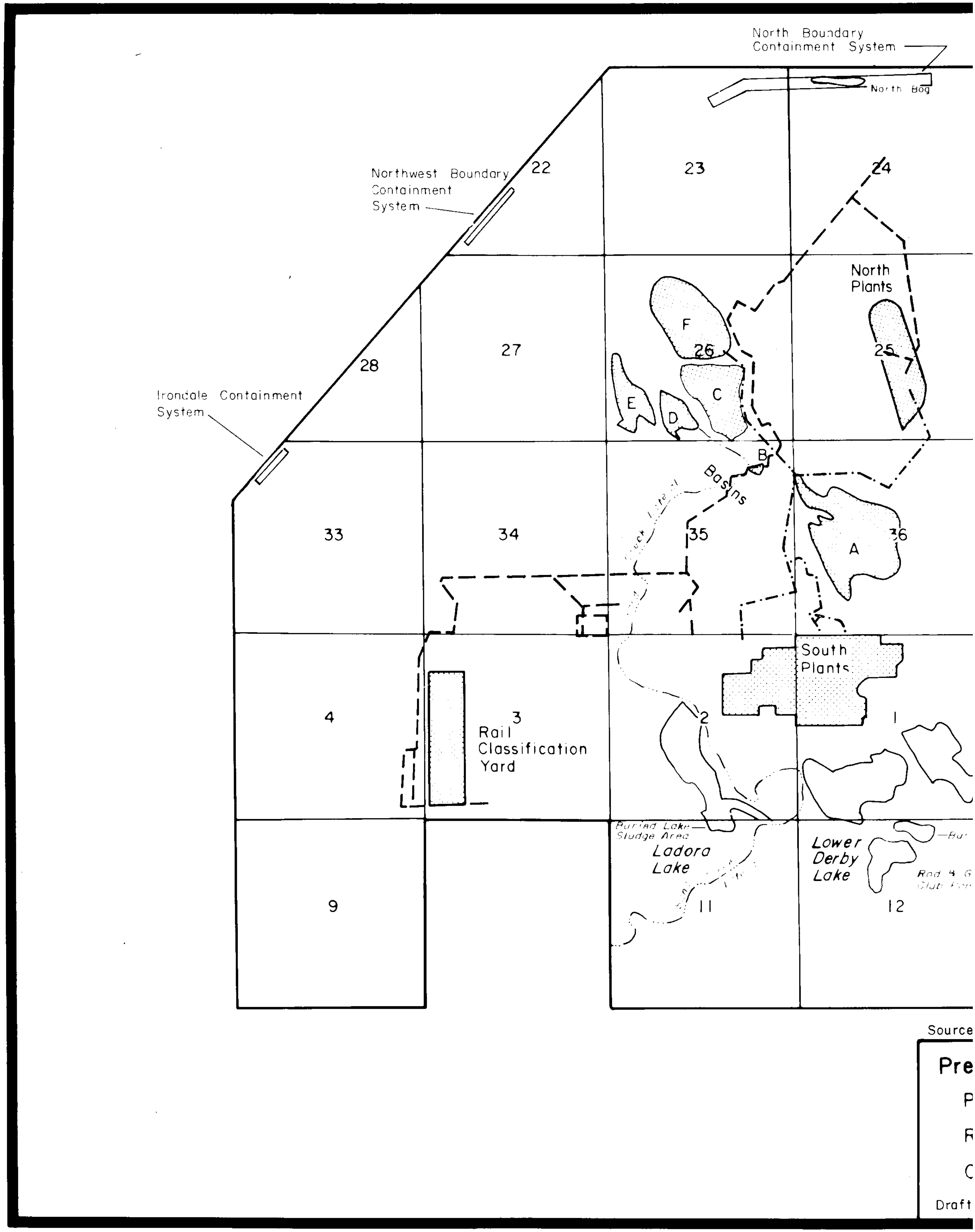
CMP Ground-Water Monitoring Technical Plan
Prepared by: R.L. Stollar and Associates, Inc.

As early as 1951, waterfowl mortality was suspected of being linked to the contamination by insecticides of three artificial lakes located on the Arsenal. In 1954 and 1955, farmers northwest of RMA using well water for irrigation reported severe crop losses (HEW Public Health Service, 1965). In 1974, two contaminants, diisopropylmethyl-phosphonate (DIMP), which is a by-product in the manufacture of the nerve agent GB, and dicyclopentadiene (DCPD), a chemical used in insecticide production, were detected in off-post surface water. Since 1978, dibromochloropropane (DBCP), a nematocide shipped from RMA by rail from 1970 to 1975, has been detected in off-post ground water. Off-post DBCP contamination of ground water still persists north of RMA.

The introduction of contaminants to the environment at RMA has occurred primarily as a result of burial or surface disposal of solid wastes, discharge of waste waters to basins, and leakage of waste waters and industrial fluids from chemical and sanitary sewer systems. Industrial wastes and industrial products that were not manufactured to specification were commonly disposed of in shallow trenches at depths of less than 10 feet. Munitions were destroyed and disposed of in trenches and on the ground surface. Waste waters generated by Army and private industrial processes in the South Plants and North Plants areas were, at various times throughout the history of RMA operations, discharged to a series of unlined evaporation and holding basins (Basins A through E) and to asphalt-lined Basin F.

The primary sites that may be contributing to ground-water contamination at RMA are the manufacturing areas, the waste storage basins (Basins A, C, D, E, and F), the solid waste disposal areas, the chemical sewer system, and locations within the rail classification yard (Figure 1.1-2).

As a result of the detection of contaminants off-site, the state of Colorado in April, 1975 issued a series of Cease and Desist Orders. In response to these orders, the Army implemented a regional sampling and hydrogeologic surveillance program through the RMA Contamination Control Program which had been established in 1974 to ensure compliance with federal and state environmental laws. The objectives of this program were to define the nature and extent of contamination, and to develop response actions to control contaminant migration. Potential and actual sources of contamination were identified, pathways by which contaminants migrate into the environment were delineated, and three ground-water control systems were installed at the northern, western, and northwestern boundaries of RMA to intercept and treat contaminated ground water and to recharge the treated water. Figure 1.1-3 illustrates the location of the ground-water control systems currently in operation with respect to contaminant distribution patterns for major contaminant groups in the alluvial ground-water system. Due to the magnitude of the overall environmental


North Boundary Containment System
North Bog
Northwest Boundary Containment System
Irondale Containment System
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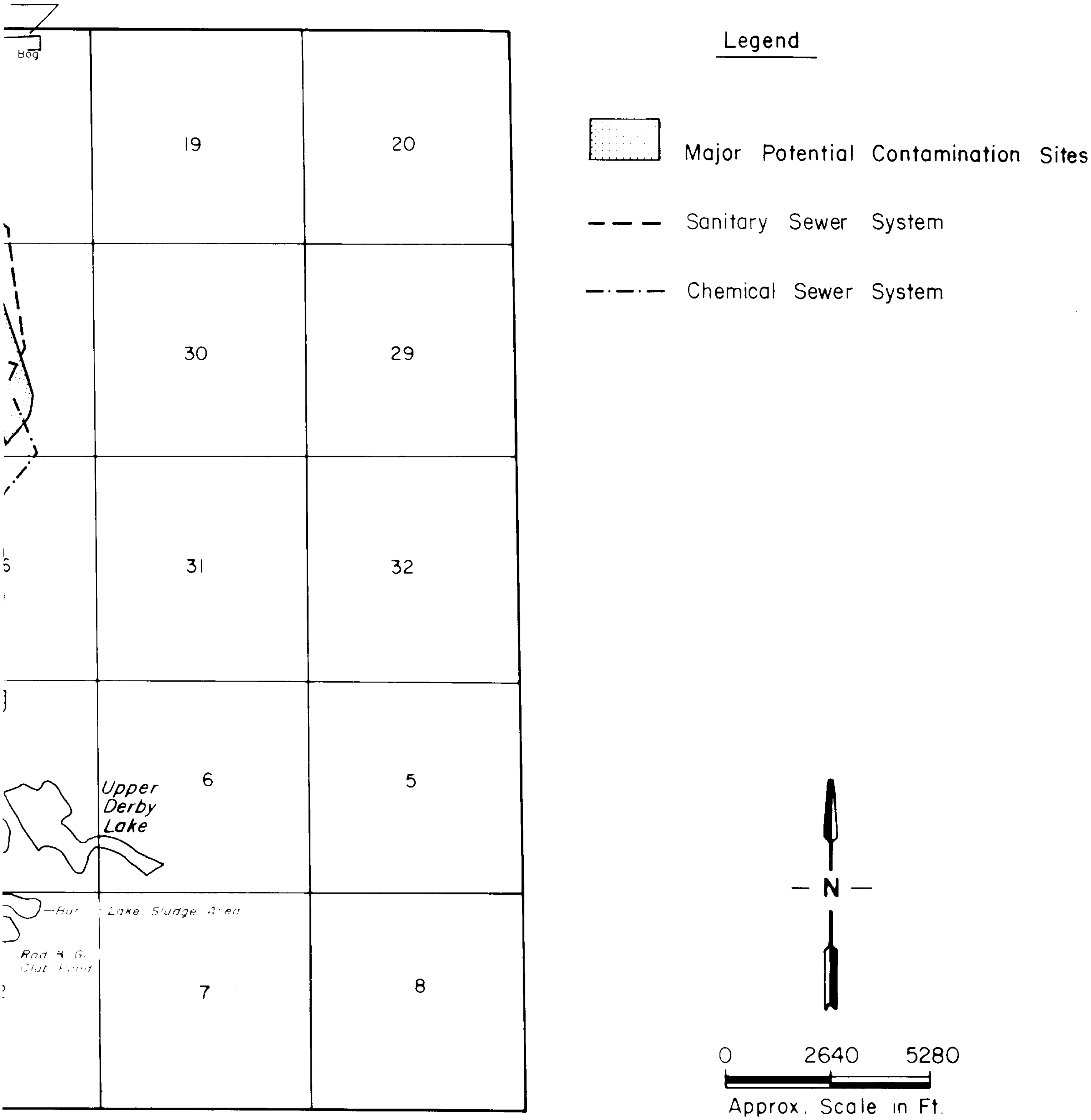

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Prepared for:

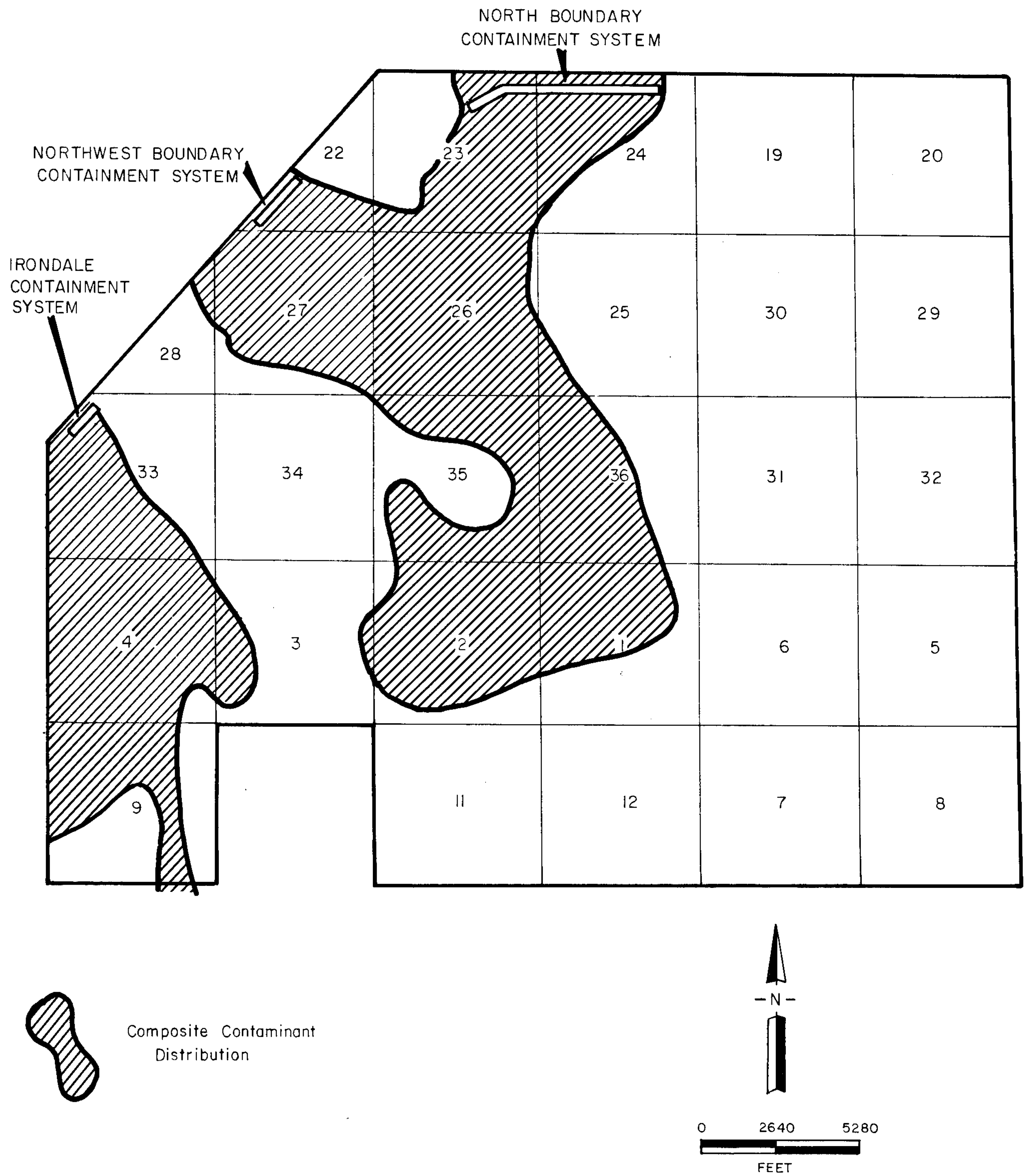
Program Manager's Office for
Rocky Mountain Arsenal Cleanup
Commerce City, Colorado

Drafted: 4/29/88, Revised: 4/26/89

FIGURE 1.1-2

Location of Major Potential Contamination Sites, Lakes and Containment Systems

CMP Ground-Water Monitoring Technical Plan
Prepared by: R.L. Stollar and Associates, Inc.



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Commerce City, Colorado

Drafted 4/29/88, Revised: 5/15/89

FIGURE 1.1-3
Generalized Composite Distribution Pattern for Major Contaminants in the Alluvial Ground Water System

CMP Ground-Water Monitoring Technical Plan
Prepared by: R.L. Stollar and Associates, Inc.

program at the Arsenal, the Program Manager's Office for the Rocky Mountain Arsenal Contamination Cleanup (PMO) was formed by the U.S. Army in 1985 to oversee remediation measures.

Since 1975, various programs have been implemented at RMA to monitor ground and surface water, to maintain surveillance over the operation of the boundary control systems and to satisfy regulatory requirements.

1.2 Purpose and Scope of the Comprehensive Ground-Water Monitoring Program

The purpose of the Comprehensive Monitoring Program (CMP) ground-water element is to provide a comprehensive long-term monitoring program of regional and site-specific ground-water hydrology and contamination conditions in both on-post and off-post areas. Specific objectives of the CMP ground-water element are to:

1. Monitor ground-water quality and ground-water hydrology to assess changes in the rate and extent of contamination and distribution of contaminant patterns in both on-post and off-post areas.

2. Maintain a regional ground-water monitoring program for regulatory data base maintenance and Remedial Investigation/Feasibility Study (RI/FS) verification purposes.

3. Maintain project area ground-water monitoring programs for regulatory data base maintenance, RI/FS verification, and system operational purposes.

The ground-water element of the CMP consists of three components: (1) a regional ground-water monitoring program which will consist of measuring water levels and collecting ground-water samples from alluvial and Denver wells both on and off-post on an annual basis; (2) a project area monitoring program which will consist of measuring water levels and collecting ground-water samples semi-annually from alluvial and Denver wells in areas requiring further definition of contaminant flow patterns; and (3) a quarterly monitoring program which will include collection of water-level measurements from an Arsenal-wide water-level monitoring network and collection of ground-water samples from alluvial and Denver wells in areas requiring detailed characterization of contamination and hydrologic conditions.

In order to achieve these objectives, work in five distinct technical areas is anticipated. These areas are as follows:

- review of historical data;

- development of monitoring programs to achieve the objectives listed above;

- execution of the monitoring programs utilizing USATHAMA-quality sampling and analytical procedures;

- assessment of the analytical data resulting from each sampling event for possible adjustments in the sampling and/or analytical scheme during subsequent sampling events; and

- compilation of the analytical data following each sampling event and contamination assessment on an annual basis.

The comprehensive ground-water monitoring program is being implemented by selection of water-level measurement and water-quality monitoring well networks using both on-post and off-post alluvial and Denver Formation wells. Water level measurements will be collected for an Arsenal-wide network of approximately 900 wells to be measured on a quarterly basis. Ground-water data will be collected annually from a regional network of wells and semi-annually and quarterly from a smaller network of project area wells.

1.3 Site Conditions

1.3.1 Geology

The topography at RMA consists of rolling hills, expansive areas of plains, and small, shallow, enclosed basins. The maximum topographic relief is approximately 220 feet. The elevation above mean sea level (msl) ranges from 5,340 feet at the south boundary to 5,120 feet at the northern boundary. The topographic surface at RMA slopes gently northwest toward the South Platte River at approximately 0.35 degrees.

RMA is located within the geologic province of a structural depression called the Denver Basin. Prior to formation of the Denver Basin in its current structural configuration, the basin area was host to a series of orogenic, transgressive, and regressive events during the Cambrian to Late

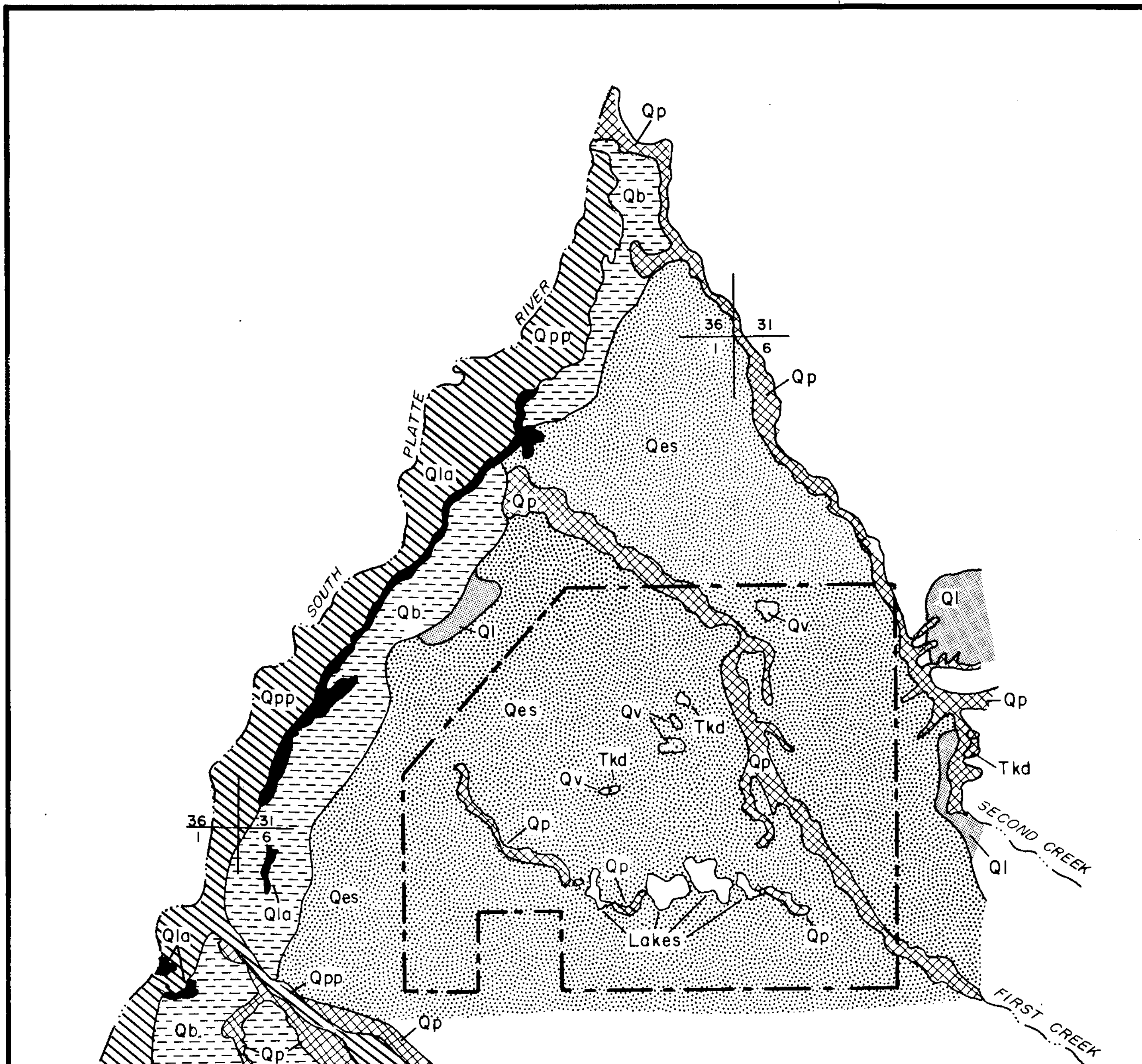
Cretaceous periods. Various sedimentary strata were deposited during this time and include conglomerate, sandstone, shale, and limestone units. The Denver Basin was downwarped to a syncline during the Late Cretaceous-early Tertiary Laramide orogeny, and the Denver Formation was deposited during this time period. Continued sedimentation occurred in the basin throughout the Tertiary period. Tertiary faulting and regional uplift eroded over 1,000 feet of sediments and carved deep paleochannels into the surface of the Denver Formation. Plate 1.3-1 shows paleochannels in the RMA area.

Sediments present at the land surface (alluvium) at RMA consist of unconsolidated alluvial and eolian deposits of Quaternary age (Figure 1.3-1). The material is composed primarily of alluvial fill, eolian sand, and glacial outwash containing cobbles, boulders, and minor beds of volcanoclastic material in a matrix of sands, gravels, silts, and clays. The combined thickness of the surficial materials ranges from 0 to 130 feet. Thicker deposits may infill paleochannels eroded into the surface of the Denver Formation, as indicated by lithologic logs from boreholes within paleochannel areas. Inferred paleochannels are shown in Plate 1.3-1. The locations of these paleochannels are currently being evaluated under the RI/FS program and may be revised based on this evaluation. Locally, deposits may be cemented by calcium carbonate forming conglomerates, sandstones, etc. The surficial material commonly is more coarse at the base, near the bedrock contact.

The Denver Formation underlying RMA consists of 250 to 400 feet of olive, bluish-gray, green-gray, and brown bentonitic claystone and siltstone. It is interbedded with poor to moderately sorted, weakly lithified, tan to brown, fine- to medium-grained sandstone. The sandstones consist of well-defined fluvial channels and less well defined crevasse splay and overbank deposits. These lenses are distributed in thick claystone sequences. Lignite beds and carbonaceous shales are common, as are volcanic fragments and tuffaceous materials. The contact between the alluvium and Denver Formation is often marked by a weathered zone in the Denver that may be up to 40 feet thick. A claystone layer ranging from 75 to 200 feet thick forms the lower portion of the Denver, the base of which marks the Denver-Arapahoe contact in the RMA area. Several regional and semi-regional RMA geologic assessments indicate that the geology and hydrology of RMA is quite complex (Ertec, 1982, RIC#83013R01; May, 1982, RIC#82295R01).

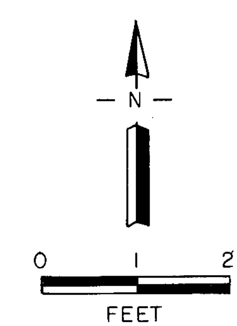
1.3.2 Ground-Water Hydrology

The Denver ground-water basin consists of a series of economically significant aquifers which are important ground-water resources. The ground-water basin underlies the area extending from Greeley, Colorado in the north to Colorado Springs, Colorado in the south and from the Front Range Uplift in the west to near Limon, Colorado in the east. Formations ranging in age from



Legend

Qpp	Post Piney Creek Alluvium (Quaternary)
Qp	Piney Creek Alluvium (Quaternary)
Qes	Eolian Sand (Quaternary)
Ql	Loess (Quaternary)
Qb	Broadway Alluvium (Quaternary)
Qla	Louviers Alluvium (Quaternary)
Qv	Verdos Alluvium (Quaternary)
Tkd	Denver Formation (Upper Cretaceous & Tertiary)



Source : USGS, 1981

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Program Manager's Office for

Rocky Mountain Arsenal Cleanup

Commerce City, Colorado

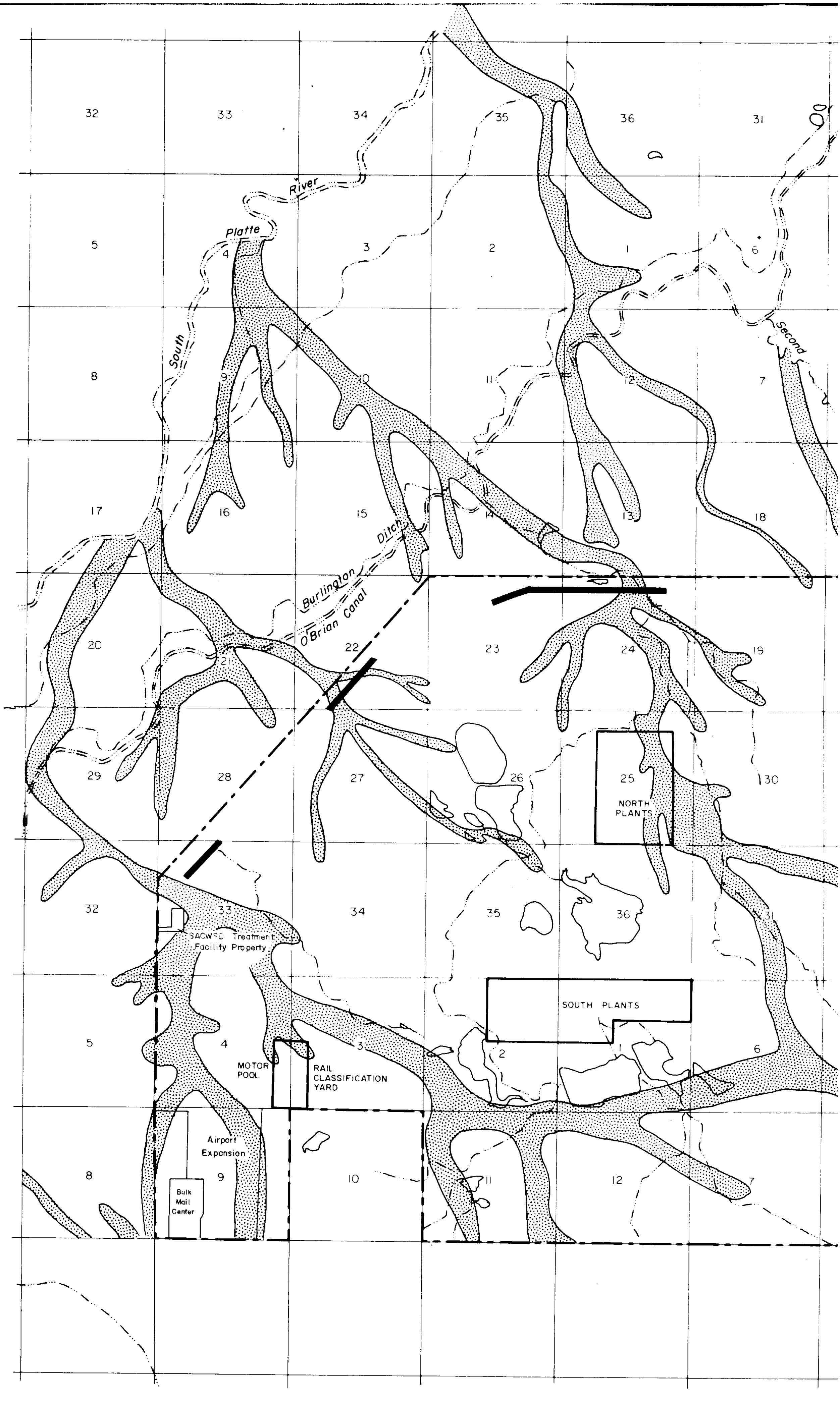
Drafted : 4/28/88

FIGURE 1.3-1

Surficial Geologic Map of Rocky Mountain Arsenal Area

CMP Ground-Water Monitoring Technical Plan

Prepared by: R.L. Stollar and Associates, Inc.



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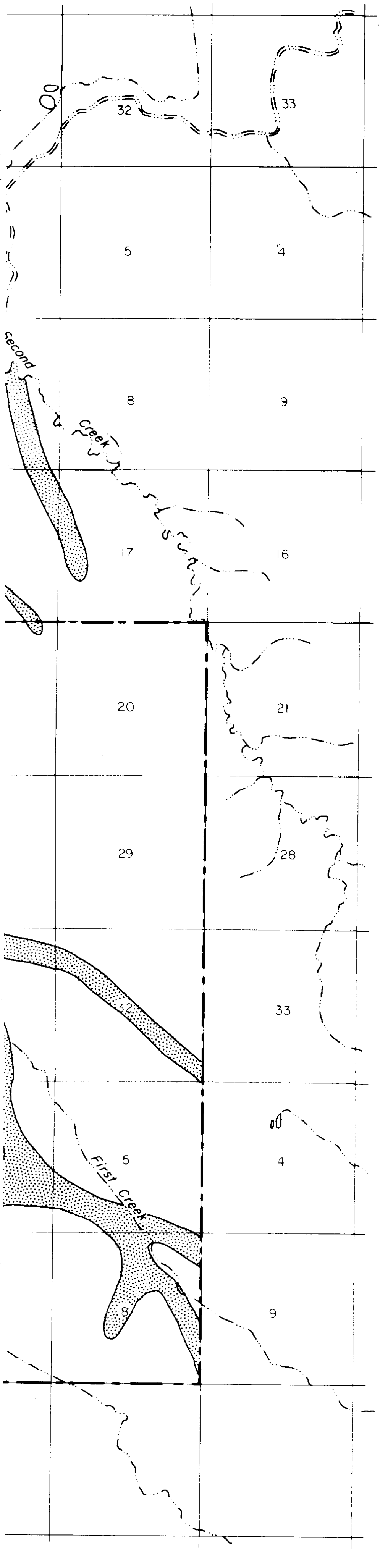

Inferred Bedrock Paleochannel

Boundary System

Source: ESE, 1988

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Commerce City, Colorado

Drafted: 10/2/88

PLATE 1.3-1

Generalized Bedrock Paleochannels

CMP Ground-Water Monitoring Technical Plan

Prepared by: R.L. Stollar and Associates, Inc.

Pennsylvanian to Tertiary contain water-bearing units. Surficial alluvial deposits and Front Range crystalline rocks may locally yield enough water to be considered aquifers.

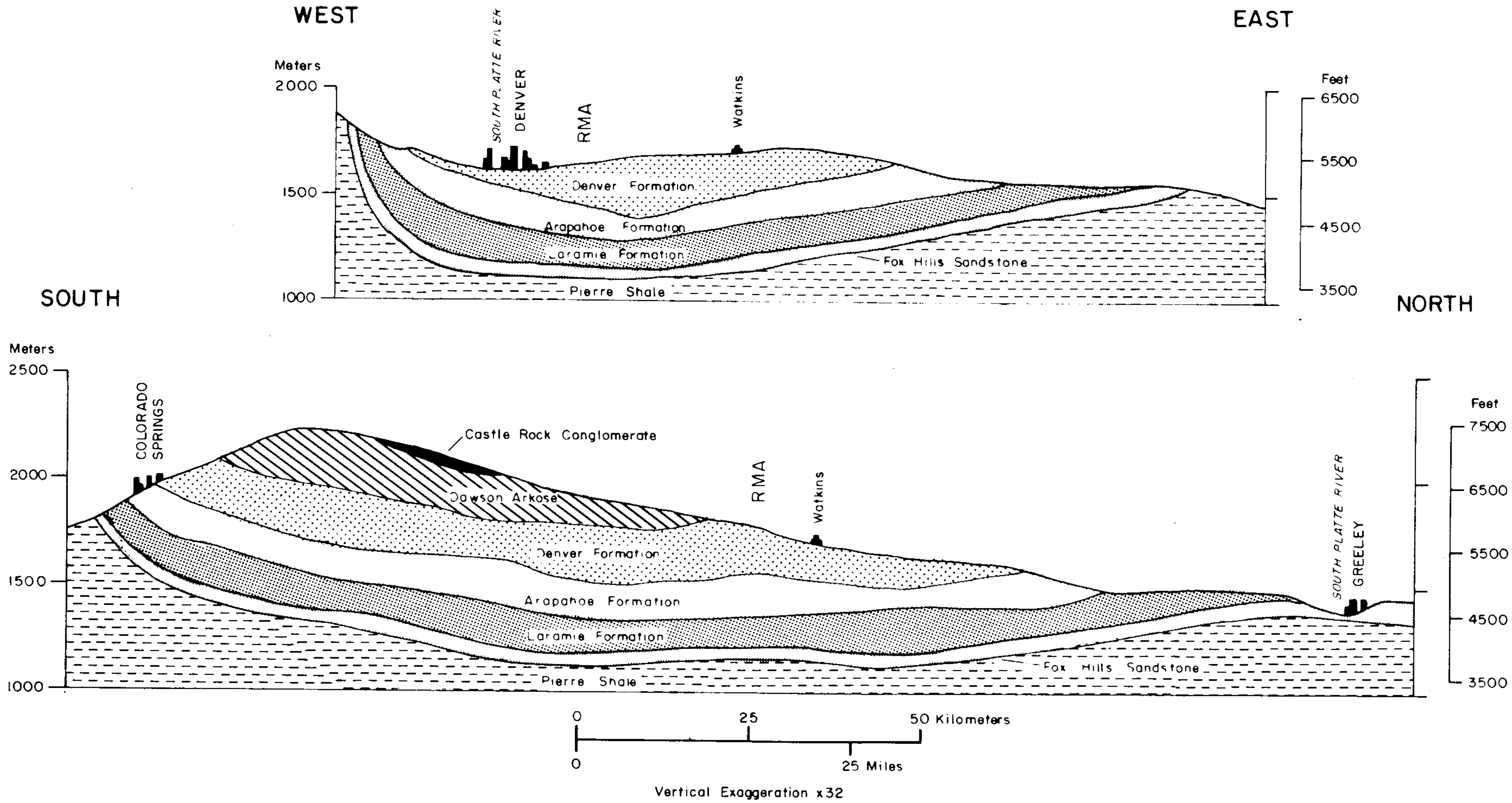
The Late Cretaceous Fox Hills Sandstone, Laramie, and Arapahoe Formations, the Late Cretaceous-early Tertiary Denver Formation, and the early Tertiary Dawson Arkose are the four major bedrock aquifers in the Denver Basin (Romero, 1976, RIC#81266R69). The stratigraphic relationship of these formations is shown in generalized geologic cross sections drawn from west to east and from south to north through the basin (Figure 1.3-2). The Late Cretaceous Pierre Shale underlies the Fox Hills Sandstone and is considered the base of the major bedrock-aquifer system because of its great thickness and its minimal permeability (Robson and Romero, 1981, RIC#82350M02).

Two major hydrogeologic subdivisions of the Denver ground-water basin are of primary concern at RMA. The Denver Formation and the unconsolidated Quaternary alluvial and surficial eolian deposits contain aquifers that comprise the shallow ground-water regime under RMA.

The entire sequence of surficial alluvial materials is considered capable of bearing water. The saturated thickness of the alluvium varies from 0 to over 60 feet at RMA, with greatest saturated thicknesses occurring in the west and southwest areas of RMA. Approximately 20 to 25 percent of the alluvium underlying RMA is unsaturated (Plate 1.3-2). Overall hydraulic conductivity of alluvial deposits is locally enhanced by coarser materials, particularly at the base of the alluvium where gravels, cobbles, and boulders may infill paleochannels incised into the Denver Formation. These paleochannels are major ground-water transport pathways, particularly in areas where alluvial flow is confined to the paleochannels. However, paleochannels appear to exhibit less control on ground-water flow and contaminant transport where alluvial ground-water flow is not confined to paleochannels (i.e., where saturated thickness is greater than the incised depth of the paleochannel). The alluvial aquifer is generally unconfined and under water table conditions, although clay lenses may produce locally perched or confined conditions.

As estimated from pumping tests, the hydraulic conductivity of the alluvial aquifer ranges from approximately 2.1×10^{-1} to 2.1×10^{-4} feet per second (ft/sec) (May, 1982, RIC#82295R01). Higher hydraulic conductivity values are associated with paleochannels. Transmissivity values in the alluvium range from 1,500 to 250,000 gallons per day per foot (gpd/ft), and the storage coefficient ranges from 0.1 to more than 0.4 (RMACCPMT, 1983, RIC#83326R01).

The Denver aquifer is composed primarily of lenses of weakly cemented to compacted, fine- to medium-grained sandstones contained within the fine-grained shales and siltstones. These



Source : Robson, 1981

Prepared for :	FIGURE 1.3-2
Program Manager's Office for Rocky Mountain Arsenal Cleanup Commerce City, Colorado	Upper Stratigraphic Sections of Denver Basin
Drafted : 4/29/88	CMP Ground-Water Monitoring Technical Plan Prepared by : R.L. Stollar and Associates, Inc.

lenticular sandstones grade laterally into relatively impermeable silts and clay shales. Primary ground-water transport takes place in the lenses and paleochannels where flow occurs in the intergranular pores within coarser materials. Ground-water transport can also occur in the fractured shales that are associated with the alluvial/Denver Formation contact. The individual sandstone units within the Denver Formation may form separate, distinct, water-bearing zones. The Denver aquifer occurs under confined conditions over much of the RMA site. However, in specific locations where the alluvium is unsaturated, water table conditions may exist in the weathered upper portion of the Denver Formation.

As determined from in situ and laboratory tests, the hydraulic conductivity of the Denver sands is approximately 10^{-4} to 10^{-6} ft/sec compared to 10^{-8} ft/sec for the claystone (May, 1982, RIC#82295R01). The transmissivity of the Denver sands range from 10 to 1×10^{-5} gpd/ft, and storage coefficients are highly variable, ranging from 10^{-5} to 10^{-8}.

The patterns of ground-water flow in the two primary aquifers (alluvial and Denver) are complicated by the following factors:

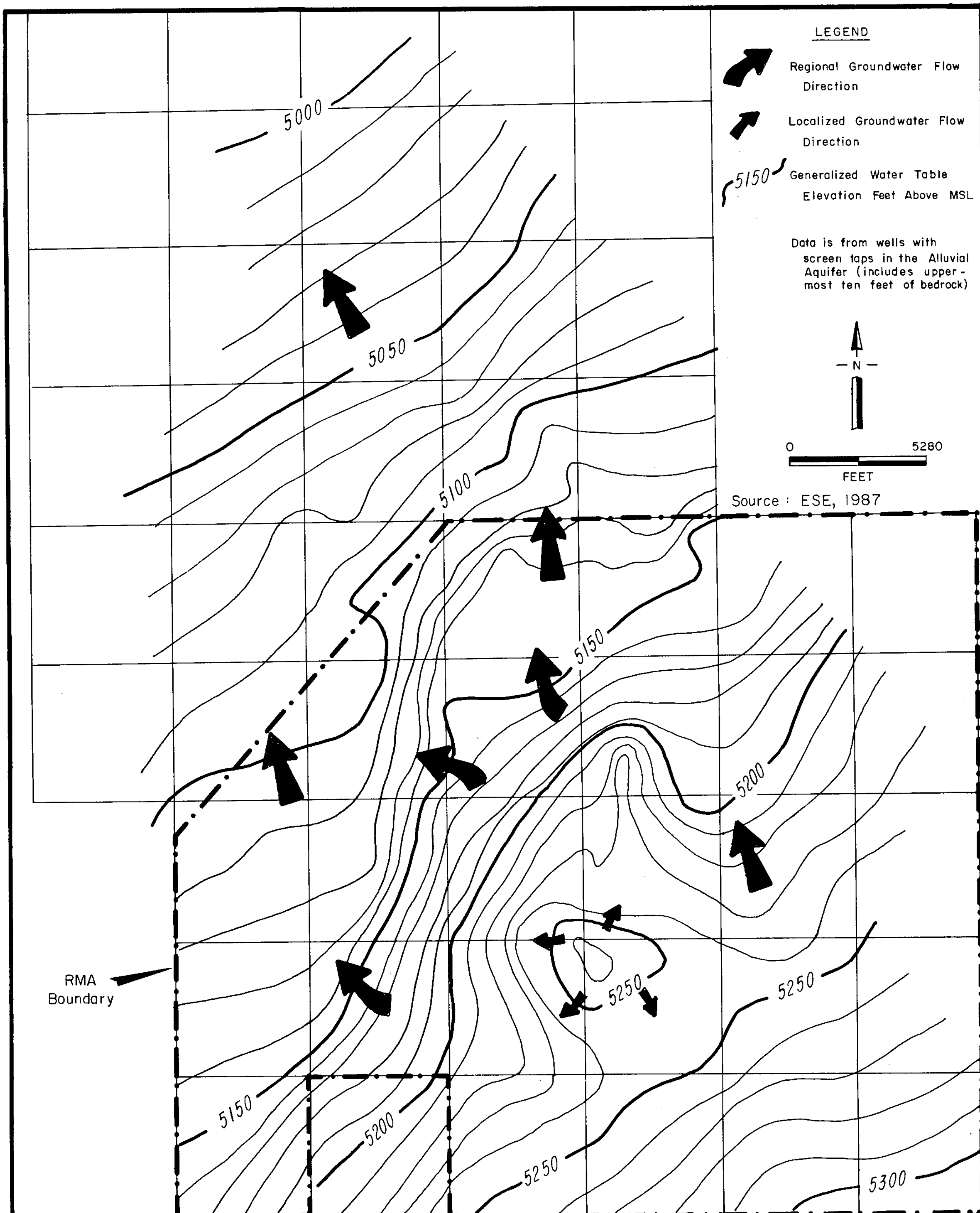
- contrasts in hydraulic conductivity between coarse alluvial sediments within the paleochannels and adjacent less permeable alluvium;

- hydraulic communication between the alluvium and the Denver sands as well as the degree of hydraulic connection between water bearing units within the Denver Formation; and

- contrasts in hydraulic conductivity among and between the Denver sandstones, adjacent claystones, and overlying alluvial materials.

Flow within the alluvial aquifer generally occurs in a north to northwesterly direction. Generalized ground-water flow directions are depicted in Figure 1.3-3. Deviations from these general patterns may occur as a result of alluvial sedimentologic and stratigraphic variations. Deviations are also caused by recharge in some areas such as the South Plants, where a large ground-water mound has been observed.

The primary source of recharge to the alluvium is from surface water and the infiltration of precipitation that occurs on-post and upgradient of RMA. Ground water in the alluvial aquifer flows laterally off site to the north and northwest and eventually discharges to the South Platte



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Commerce City, Colorado

Drafted: 4/26/88

FIGURE 1.3-3

Generalized Alluvial Water Table and Dominant Alluvial Ground-Water Flow Directions

CMP Ground-Water Monitoring Technical Plan

Prepared by: R.L. Stollar and Associates, Inc.

River. Where a downward vertical hydraulic gradient exists, there is a small component of flow from the alluvium into the uppermost Denver Formation.

Ground-water flow within the Denver Formation occurs in a generally north to northwesterly direction. The confining effect of the claystones and the upgradient off-post recharge of the Denver aquifer produces artesian conditions in much of the Denver aquifer underlying RMA. Recharge to the Denver Formation occurs as a result of downward flow from the overlying Dawson Arkose aquifer south of RMA, precipitation infiltration on the Denver Formation outcrops along the western margin of the Denver basin, and downward flow from the overlying alluvial aquifer (Ertec, 1982, RIC#83013R01) (Figure 1.3-4). Discharge from the Denver aquifer may occur as flow into the underlying Arapahoe aquifer, recharge to the overlying alluvial aquifer, and discharges associated with wells. Because of a thick confining layer (buffer zone) in lower Denver Formation recharge to the Arapahoe Formation in the vicinity of RMA is insignificant.

The relative complexity of the ground-water regime in the area is due to intricate geologic, stratigraphic, and topographic relationships between and within the Denver Formation and the overlying surficial deposits. The alluvial and Denver aquifers are locally isolated from each other by semipermeable confining layers that restrict flow between the more permeable strata. Flow between the more permeable strata occurs where confining beds are absent, creating interconnections between aquifers.

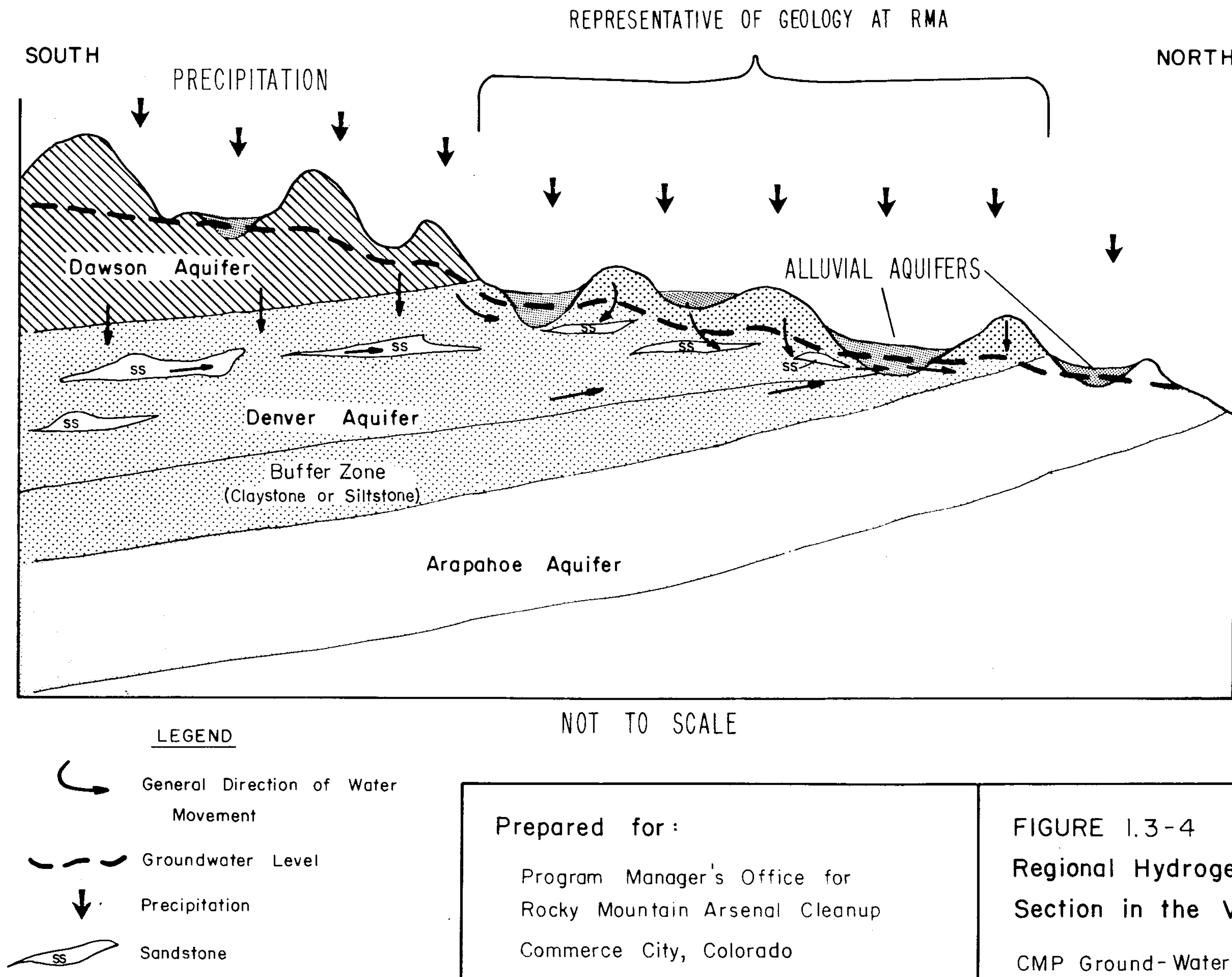
1.4 Water Quality Monitoring Programs

This section provides a description of previous ground-water quality monitoring programs at RMA and discusses how these programs are related to the CMP.

1.4.1 Previous RMA Ground-Water Monitoring Programs

A significant effort has been devoted to monitoring RMA ground-water quality over the past 10 years. Approximately 1,800 wells have been installed at RMA. Although a large ground-water data base has been compiled, the majority of these wells have not been sampled on a routine basis and a number of the wells are dry, destroyed, obstructed, or poorly documented with respect to construction and completion.

Historical ground-water monitoring efforts have included several monitoring programs designed to accomplish a variety of objectives. Regional monitoring programs have included the 360-Degree



Source: RMA-CCMT, 1983

Prepared for:

Program Manager's Office for Rocky Mountain Arsenal Cleanup

Commerce City, Colorado

Drafted: 4/29/88, **Revised: 4/26/89**

FIGURE 1.3-4

Regional Hydrogeologic Flow Section in the Vicinity of RMA

CMP Ground-Water Monitoring Technical Plan

Prepared by: R.L. Stollar and Associates, Inc.

Monitoring Program (1975-1985) and two consecutive tasks performed during the Remedial Investigation/Feasibility Study (RI/FS) contract: Task 4 (1985-1986) and Task 44 (1987).

The initial 360-Degree Monitoring Program was a regional surveillance program initiated in response to the 1975 Cease and Desist Order issued by the Colorado Department of Health (CDH). Ground water and surface water were actively monitored by this program from 1975 through 1985. This program was supported by the Memorandum of Agreement (MOA) parties which included the Army, the Colorado Department of Health (CDH), Shell Chemical Company (SCC), and the U.S. Environmental Protection Agency (EPA).

The 360-Degree Monitoring Program initially consisted of 153 wells and surface water sites. The number and specific location of wells sampled under this program were periodically modified between 1975 and 1985 because selected wells were abandoned and new ground-water monitoring wells were installed. In 1976, approximately 55 monitoring wells were added to the 360-Degree Program, including many wells located north and northwest of the RMA boundary. In 1985, 43 off-post wells were added to the program. Water level data were collected during the 360-Degree Program from 490 monitoring wells on a quarterly basis in 1985.

In 1985, the on-post portion of the 360-Degree Program was replaced by the Task 4 Monitoring Program. Water-level data from the Task 4 program were examined to establish directions of ground-water flow within the alluvium and to aid in the correlation of permeable units within the Denver Formation. Water-quality information from Task 4 and, as appropriate, from the historical data base were examined to formulate an assessment of the distribution of contaminants within the RMA ground-water system.

In 1987, Task 4 was replaced by the Task 44 regional monitoring program. Task 44 incorporated 43 off-post wells from the 360-Degree Program and many of the Task 4 wells. Task 44 was designed to assess the areal and vertical extent of ground-water contamination at RMA, to satisfy the requirements of Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), and to develop a core data base of verified water-quality data to be used by the RI/FS contractors and for litigation.

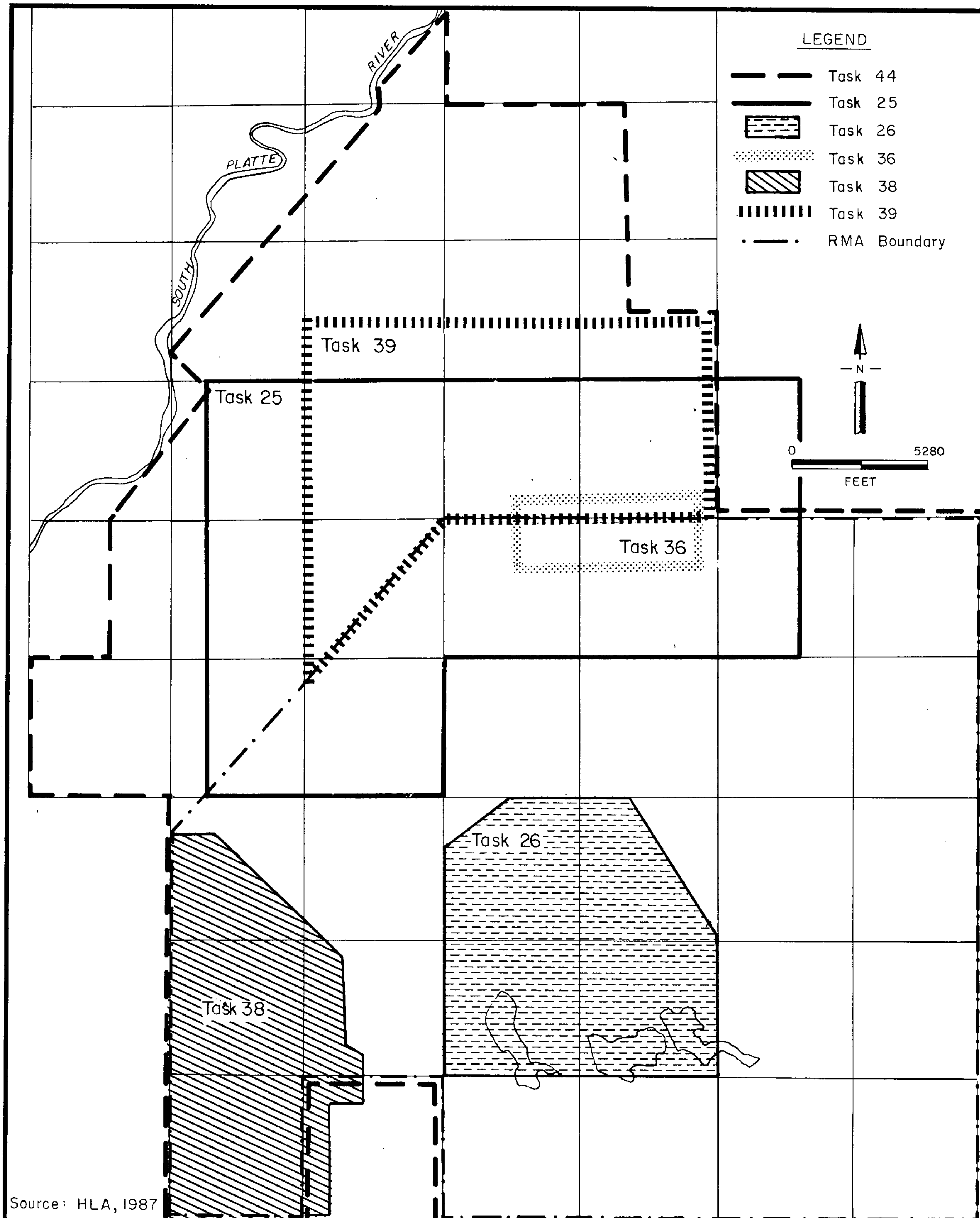
Monitoring programs addressing specific areas prior to 1985 included the Basin F Monitoring Program, the North Boundary Containment System (NBCS) Program, the Northwest Boundary Containment System (NWBCS) Program, and the Irondale Containment System (ICS) Program. These individual programs were designed to achieve specific objectives in localized portions of RMA.

Since 1985, specific area ground-water monitoring programs have included the ICS Program and Tasks 6 (off-post), 25 (NBCS and NWBCS), 26 (South Plants/Basin A), 36 (NBCS), 38 (Western Tier), and 39 (off-post). Like the pre-1985 tasks, these efforts were designed to satisfy specific objectives and augment the Task 44 program, which included specific areas like Basin F (Figure 1.4-1).

The findings of the initial (360°) regional ground-water monitoring program documented off-post discharge of contaminants in three general areas. To prevent continued off-post migration of RMA contaminants in these areas, three boundary control systems were constructed and are currently operating. The pilot NBCS, activated in 1978 and expanded in 1981, and the NWBCS, activated in 1984, are operated by the Army. Both of these systems consist of a soil/bentonite slurry wall, a line of extraction wells located upgradient of the slurry wall, a water treatment system, and a series of recharge wells on the downgradient side of the slurry wall. The ICS, activated in 1981, is operated by SCC on the western border of RMA and forms a hydraulic barrier to off-post contaminant transport. This system includes two lines of extraction wells, a water treatment system, and a line of recharge wells.

Historically, the NBCS Monitoring Program included sampling of 80 on-post and off-post wells in the alluvial and Denver aquifers. Samples from these wells were collected on a quarterly basis but were collected more frequently if problems with the system arose or if operational parameters were changed. The NWBCS has historically been monitored using 45 on-post and off-post monitoring wells sampled on at least a quarterly basis. The ICS was constructed and is operated by SCC, which supervises collection and analysis of the water samples associated with operation of the system. Thirty-six wells are sampled quarterly in support of the operation of this system.

In addition to the programs described above, a number of other ground-water related programs have been conducted in the past. These programs include the North Boundary Study, North Boundary Pilot Containment System, Northwest Quadrant, and Nemagon Sampling Programs, all precursors to the various boundary containment monitoring programs. The Basin A Neck program was also conducted to examine the feasibility of installing a barrier system in this area. In addition, several discrete investigations of the ground-water quality at RMA were conducted. These programs were conducted by either the U.S. Army Waterways Experimental Station (WES) or SCC. Other water-quality investigations were conducted by the RMA Environmental Division (RMA-ED) under the Basin F Study, Regional Sampling, or Source Identification Programs. These ancillary programs did not involve long-term continued monitoring. However, the results of these programs were evaluated and utilized in the development of the CMP monitoring network.



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Program Manager's Office for
Rocky Mountain Arsenal Cleanup
Commerce City, Colorado

Drafted: 4/26/88

FIGURE 1.4-1

Areal Extent of Task 44 and Other Related Groundwater Programs

CMP Ground-Water Monitoring Technical Plan

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1.4.2 Relationship of the CMP to Previous Ground-Water Monitoring Programs

The CMP includes both regional monitoring and specific area monitoring. The CMP regional monitoring program replaces the regional and site-specific monitoring program conducted under Task 44 of the RI/FS. The CMP specific area monitoring encompasses monitoring at the NBCS and NWBCS previously conducted under Task 25 as well as monitoring of several other specific areas. A monitoring well network has been designed that fulfills the requirements of each of these programs in accordance with the objectives of the CMP listed in Section 1.2.

Data obtained under each of the previous RMA ground-water monitoring programs will be integrated with data obtained during the CMP. These data will be used to assess changes in the nature and extent of ground-water contamination at RMA over time. Data will also be used to evaluate the adequacy of the CMP monitoring well network as new wells become available for sampling.

2.0 COMPREHENSIVE GROUND-WATER MONITORING PROGRAM

The purpose of the Comprehensive Monitoring Program (CMP) is to provide continued hydrogeologic and water-quality assessment for the RMA on-post and off-post areas. The CMP assessment involves monitoring of general area wells and project area wells. The network design involves the review of historical data in which a large number of wells were evaluated with respect to construction details, historical water quality, sampling history, location, and well hydraulics.

The rationale for design of the CMP monitoring network is discussed in Sections 2.1.1 through 2.1.3. Criteria for evaluating the wells are described in Sections 2.2.1 through 2.2.4. The resulting CMP ground-water monitoring networks are described in Section 2.3. The proposed water quality sampling frequency and schedule is outlined in Section 2.4. The chemical analytical schedule for the CMP ground-water sampling is addressed in Section 3.0. Ground-water sampling data will be assessed following each sampling event to determine possible adjustments in the sampling and/or analytical scheme. Analytical data collected during each of the sampling events will be compiled according to the data management plan described in Section 8.0 and used in conducting an annual contamination assessment as described in Section 6.0.

The principles involved in development of the CMP Ground-Water Monitoring Technical Plan as well as the actual well selection process were developed through a series of working sessions attended by technical representatives of the Army, Shell and their contractors. Future modifications to this technical plan or changes in the monitoring well networks will be made using a similar approach with all organizations involved in the RMA cleanup program.

2.1 Network Design Rationale

The ground-water monitoring network for the CMP at RMA includes wells for both water-quality and water-level monitoring. The network encompasses wells from both the on-post and off-post areas. The overall philosophy for network design was to provide the most efficient network that would meet the objectives of the program. The most efficient network was selected by using the best combination of monitoring wells, monitoring frequency, and analytical suite that would achieve the program goals.

The overall objectives of the CMP were detailed in Section 1.2. In brief, the objectives of the CMP monitoring network are to provide data to:

- monitor ground-water quality and ground-water hydrology to assess changes in the rate and extent of contamination and distribution of contaminant patterns in both on-post and off-post areas;

- maintain a regional ground-water monitoring program for regulatory database maintenance and RI/FS verification purposes; and

- maintain project area ground-water monitoring programs for regulatory database maintenance, RI/FS verification, and system operational purposes.

A secondary objective of the monitoring program is to provide data for design of planned remedial facilities when collection of these data could reasonably be undertaken within existing CMP contract guidelines. An assessment of the ability of the CMP to meet these remedial design needs will be undertaken on a case-by-case basis as the needs arise. If needed data cannot be obtained under the CMP scope of work, the additional data will be collected under a separate contract overseen by either the PM RMA or SCC.

2.1.1 Design Rationale for On-Post Water-Quality Monitoring

The RMA area on-post has been studied extensively for more than a decade. As a result, there is a great deal of existing information that was available to guide the monitoring network design. The philosophy of monitoring water-quality in the on-post area was shaped by the current evaluations of contaminant distribution, source area locations, and existing remedial facility locations.

A two-tiered approach was used in designing the on-post monitoring network. This approach involved the designation of two area types corresponding to each of the two tiers as indicated below:

- general areas, and

- project areas.

Project monitoring networks are described in Section 2.3. In essence, the general areas are ones where monitoring will be used to confirm presently understood contaminant distributions and monitor for changes in these distributions. Project areas are those where an improved definition

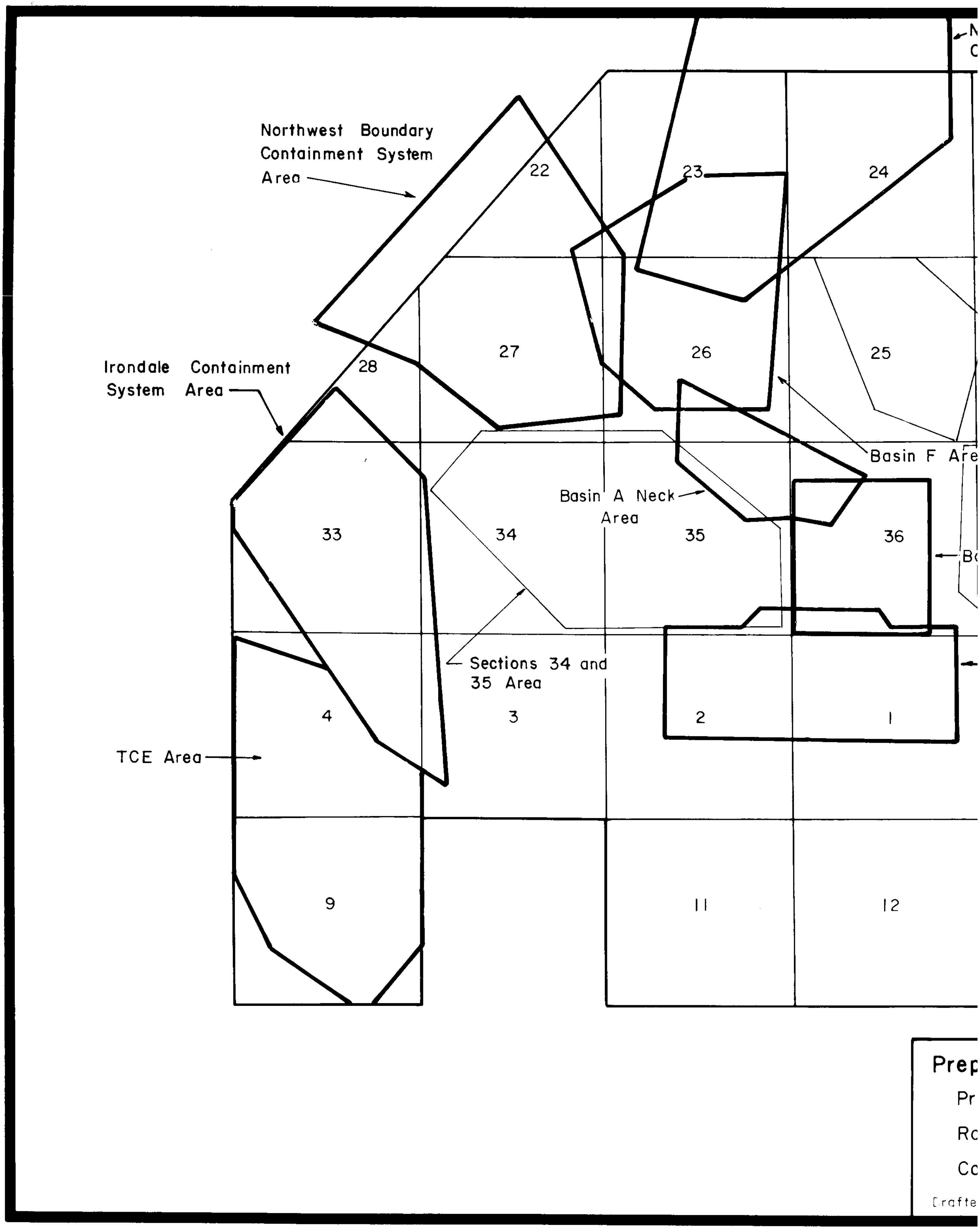
of contaminant distribution is sought. This approach to monitoring provides for confirmation of existing knowledge and collection of more detailed information where it is needed in the most efficient manner currently possible. Each of the area types are shown in Figure 2.1-1. The general areas in this figure are all areas outside of designated project area boundaries. More detailed descriptions of each area type are given below.

2.1.1.1 General Areas. General areas are defined as areas where less definition of water quality is required and, therefore, the network of monitoring wells is less densely spaced. In general areas sampling will occur on an annual (once per year) basis. General areas may include areas of known contamination or they may be in areas where contamination has not been detected. Where no contaminants have been detected, the selected wells will be monitored to allow confirmation that contamination is not moving into these areas. Where contamination is present, general areas are those areas where existing data have allowed contaminant distributions to be sufficiently well defined, both spatially and temporally. The current level of spatial and temporal understanding provides ample technical justification for a less densely-spaced network that is sampled on an annual basis.

2.1.1.2 Project Areas. Project areas are defined as those areas where, in contrast to the general areas described above, both additional data collection on a more frequent basis and more dense spacing of wells is needed to maintain and improve if necessary, understanding of site conditions. In these areas, water-quality monitoring will be conducted on a semi-annual basis (twice per year). One of these two events will be conducted at the same time as the annual monitoring of wells in general areas as described in the previous section. A more detailed discussion of the frequency of sampling for the entire network is provided in Section 2.4.

Project areas were delineated where contamination is known to exist but where additional information regarding the flow paths of the contaminants through the areas is required. These data may be used to more fully assess the effectiveness of boundary control systems or may be used to highlight areas where remedial actions are expected and where additional data collection should be focused for remedial design.

Eight designated project areas and three tentative project areas have been identified for more focused monitoring using the criteria described above (Figure 2.1-1). These areas include:



Northwest Boundary Containment System Area
Irondale Containment System Area
Basin A Neck Area
Basin F Are
Sections 34 and 35 Area
TCE Area
22
23
24
27
26
25
28
33
34
35
36
4
3
2
1
9
11
12
Prep
Pr
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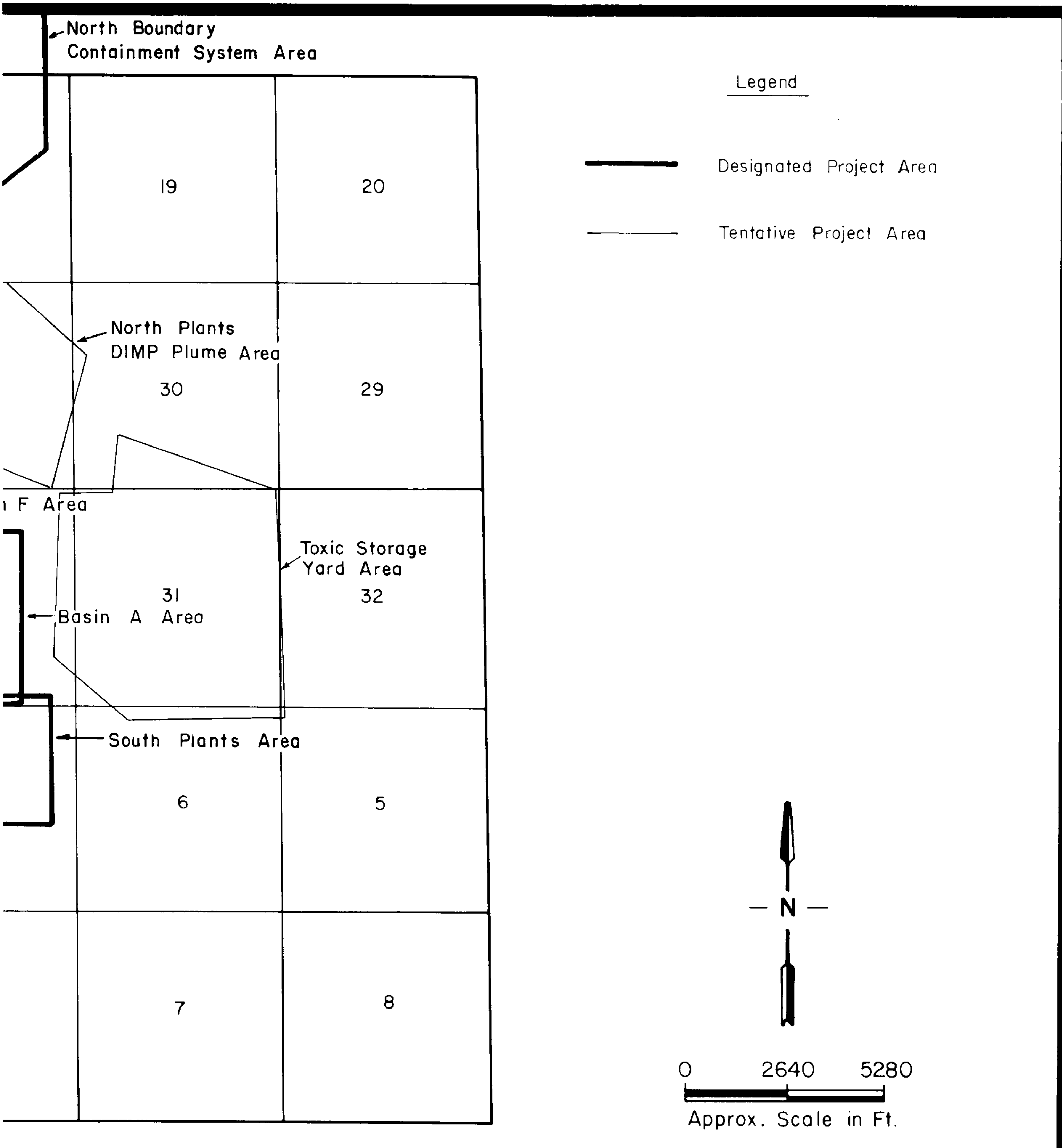
Crafte



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Commerce City, Colorado

Crafted: 4/29/88, Revised: 5/15/89

FIGURE 2.1-1

Project Areas in the Comprehensive Ground-Water Monitoring Program

CMP Ground-Water Monitoring Technical Plan
Prepared by: R.L. Stollar and Associates, Inc.

1. The North Boundary Containment System Area - This area was delineated because of the ongoing need to assess the system's effectiveness and to support the data requirements of system operation. A remedial action assessment to evaluate the effectiveness of the NBCS is currently being performed as part of the RI/FS process. Data and recommendations from RI/FS Task 36 will be considered and modifications to current design of the NBCSA network will be made if needed. Focused monitoring will support the remedial action assessment findings and will allow an assessment of the effectiveness of any remedial actions.

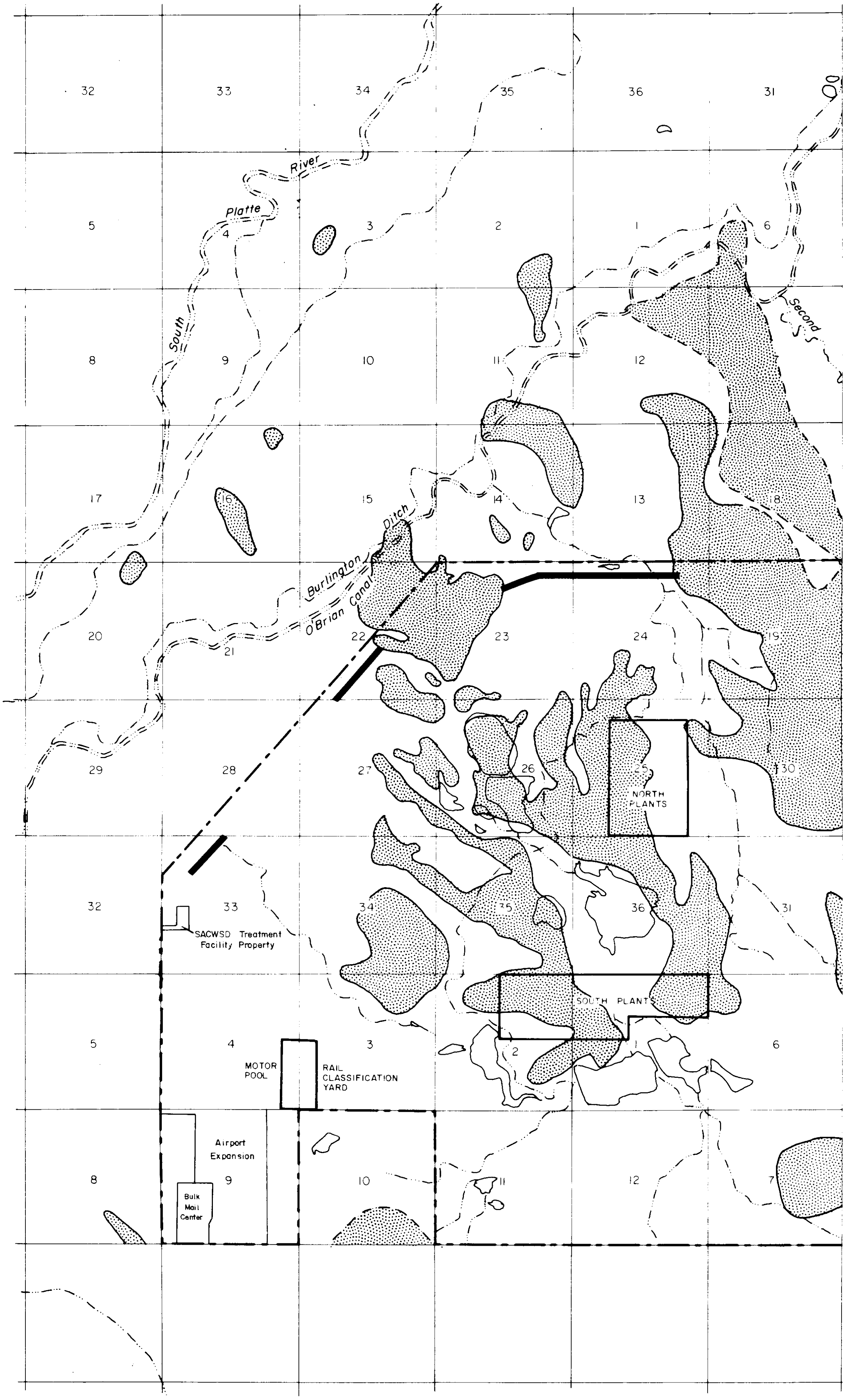
2. Northwest Boundary Containment System Area - This area was delineated because of the ongoing need to assess the system's effectiveness and to support the data requirements of system operation.

3. Irondale Containment System/DBCP Plume Area - This area was delineated for the same reasons as the containment systems described above. In addition, this area was delineated in order to provide focused monitoring of the DBCP plume to provide further information concerning its spatial and temporal variations.

4. The TCE Area - This area was delineated in order to monitor the flux of TCE on RMA and flow paths associated with potential on- and off-post contaminant sources.

5. Basin A Neck Area - Focused monitoring in the Basin A Neck area will allow continued monitoring of the rate and extent of contamination movement. It is anticipated that remedial activities will be performed in this area and, therefore, additional monitoring in this area should be performed to focus future data collection in support of remediation design.

6. South Plants Area - Long-term monitoring in the South Plants Area is needed to assess the rate and extent of contamination in this source area. This need was recognized and steps to collect the needed data have been undertaken by Shell. In addition, a specific area ground-water monitoring network has been designed under the CMP for the South Plants Area. This network will be modified based on the Shell results, if necessary.



South Platte River
Second
Burlington Ditch
O'Brian Canal
NORTH PLANTS
SOUTH PLANTS
SACWSD Treatment Facility Property
MOTOR POOL
RAIL CLASSIFICATION YARD
Airport Expansion
Bulk Mail Center
32
33
34
35
36
31
5
4
3
2
1
6
8
9
10
11
12
7
17
16
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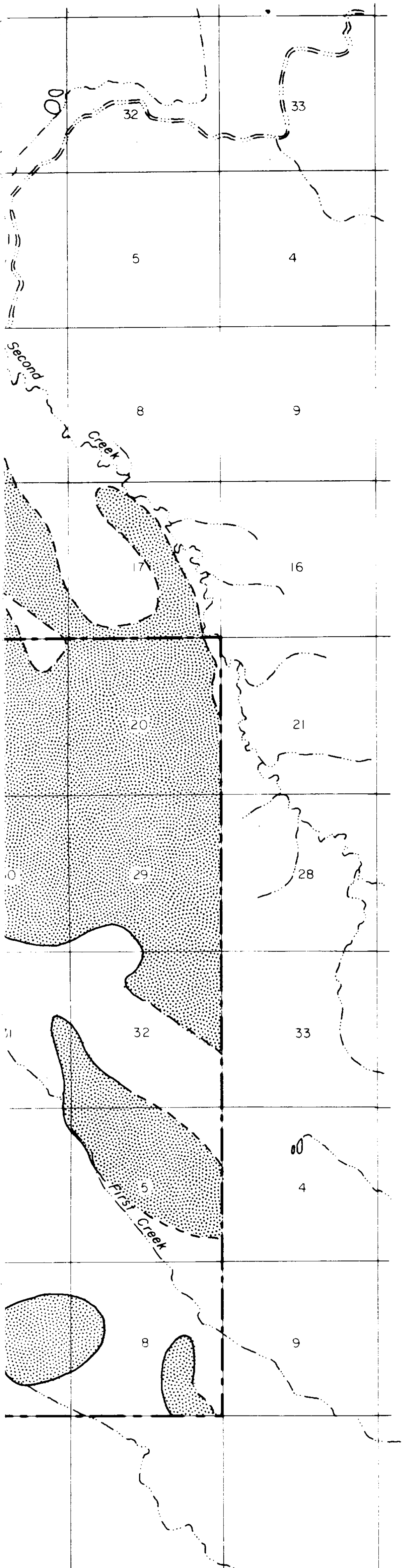


Unsaturated Alluvium

Boundary System

Source: ESE, 1988

N

0 4000 8000

FEET

Prepared for:

Program Manager's Office for

Rocky Mountain Arsenal Cleanup

Commerce City, Colorado

Drafted: 10/2/88

PLATE 1.3-2

Approximate Areal Extent of Unsaturated Alluvium

CMP Ground-Water Monitoring Technical Plan

Prepared by: R.L. Stollar and Associates, Inc.

7. Basin F Area - Maintain long-term monitoring in order to assess current contaminant distribution and potential changes due to ongoing remedial actions in this project area.

8. Basin A Area - Contaminant patterns in this project area are relatively well-defined; however, continued monitoring is needed to detect any potential changes in the rate and extent of contaminant movement.

9. North Plants Area - This tentative project area was delineated in order to monitor the potential flow of contaminants from the North Plants towards the north boundary of RMA.

10. Toxic Storage Yard Area - This tentative project area was delineated in order to monitor the potential flow of contaminants in the vicinity of the Toxic Storage Yard.

11. Sections 34 and 35 Area - This tentative project area was delineated in order to assess the potential flow of contaminants from the South Plants northwest to the Northwest Boundary Containment System Area.

2.1.2 Design Rationale for Off-post Water-quality Monitoring

Ground-water quality monitoring in the off-post area has the objective of assessing off-post contamination that is attributable to ground-water flow and contaminant transport from RMA. The monitoring network in the off-post area was designed first, to provide a spacing of monitoring wells that are of sufficient density to respond to concerns relative to consumption of contaminated ground water in the off-post region. Secondly, the network was designed to provide data that can focus future data collection efforts to support design of planned remedial activities.

The number of off-post wells has increased in response to the need for new wells in critical locations or for better quality well construction to ensure that water-quality data are reliable. If necessary, the network will be modified in response to the data from new wells. Specific criteria for selection of all wells, including those off-post, are described in Section 2.2.

2.1.3 Design Rationale for Water-Level Monitoring Network

The water-level monitoring network for the CMP includes wells both on- and off-post in both the Alluvial and Denver Formation aquifers. Wells in the Alluvial aquifer were selected to provide as

nearly as possible, an evenly-spaced distribution. A higher proportion of the existing Denver Formation wells were included in the Denver Formation monitoring network because of the complicated nature of ground-water flow in this formation.

2.2 Well Selection Criteria

The criteria used in selecting wells for the ground-water quality monitoring network are discussed in Sections 2.2.1 through 2.2.3. These criteria are applicable to the selection of wells in both on-post and off-post areas and to the selection of both general and project area wells. However, the emphasis given to many of these criteria were variable depending on whether monitoring was for the project areas or the general area network. Well selection criteria for the water-level monitoring network are discussed in Section 2.2.4

2.2.1 Selection Criteria for Wells in the General Areas

Criteria used to select wells for inclusion in the monitoring network that were common to both the alluvium and the Denver Formation included:

- quality of well construction and availability of construction record;
- current condition of the well;
- historical water-quality data;
- well location with respect to known areas of degraded water quality and potential contaminant sites;
- the presence or absence of adjacent wells completed in different hydrologic zones (well clusters); and
- the geologic and hydrologic conditions in the vicinity of the well.

The well construction evaluation utilized a grouping system developed under the RI/FS contract (ESE, 1986, RIC#87013R01). Under this system, wells were given numerical ratings to indicate the degree of acceptability for sampling based on well construction data that were then available. These terminologies were assigned largely on the presence or absence of supporting documentation. A lower numerical designation indicated the well construction was unacceptable for water-quality

monitoring while a higher designation was given to wells assessed to be the most acceptable for water-quality monitoring.

As a result of recent investigative activities, many new ground-water monitoring wells with acceptable construction ratings have been installed. Newly constructed wells will be included in the CMP network following installation and development.

The current condition of each well was evaluated with respect to sampling history. Through this evaluation, wells which could not be sampled historically were identified. The factors preventing the sampling of wells included constrictions in well casings and insufficient recharge of dewatered wells in a 24-hour period. Wells that had been abandoned or destroyed were also identified and were not considered for inclusion in the network.

For selection of project area wells, each well was evaluated based on the location of the well with respect to the areas shown in Figure 2.1-1. The historical water quality data for each well were also evaluated. Wells were selected that would provide additional information regarding contaminant migration pathways in these areas. Wells outside the areas were also evaluated with respect to historical water-quality data for possible inclusion in the general network.

Historical water-quality data for each well were evaluated based on the period of record, sampling frequency, consistency of results, and laboratory and field quality assurance and quality control data. In general, more recent water-quality data, such as those derived from Task 4 and Task 44 of the RI/FS, were thought to be the most reliable and were given highest consideration.

For project area wells, the well location with respect to known areas of water-quality degradation or potential contaminant sites were considered in two ways. First, wells near contaminant sites were emphasized to monitor the extent of vertical and horizontal contaminant migration. Second, for areas where several wells exist and data from these wells provided essentially the same information, a single well was recommended for sampling in order to eliminate data duplication.

Another evaluation criteria was the presence of adjacent wells with different screened intervals. Groups of adjacent wells with different screened intervals (well clusters) were given priority in order to provide information on vertical chemical distributions and vertical hydraulic gradients. When considering clustered wells screened within Denver Formation sand units, historical water-quality data were used to aid in selection of the well or wells to be monitored.

Geologic and hydrologic conditions in the vicinity of the wells were considered in order to evaluate the possible hydraulic communication between areas. The local horizontal flow direction was considered in conjunction with the monitored interval for each well. For example, a contaminated well in a shallow Denver Formation sand unit would indicate that sampling a downgradient well in the same sand unit may be more desirable than other sand units in order to track potential downgradient contaminant migration. In addition, monitoring of the next lower sand unit was considered in order to evaluate vertical contaminant flux.

2.2.2 Criteria Specific to the Alluvial Monitoring Well Network Design

The design of the monitoring well network in the saturated alluvium included consideration of the non formation-specific factors described above and other criteria specific to the alluvial system. The specific criteria included:

- the placement of wells in areas of saturated alluvium;
- the placement of the screened interval within alluvium;
- the presence of wells within paleochannels; and
- existing alluvial ground-water flow patterns.

There are large areas within RMA in which the alluvium overlying the Denver Formation is unsaturated. Therefore, alluvial ground-water monitoring wells are absent in these areas. However, an effort was made to include shallow Denver monitoring wells in the Denver Formation network in these areas to monitor water table conditions.

Paleochannels eroded into the surface of the Denver Formation and filled with coarse alluvial sediments (sands and gravels) are generally considered to be a dominant factor affecting ground-water flow in the alluvial aquifer. Paleochannels represent areas of higher hydraulic conductivity compared to interfluvial areas and represent areas of relatively higher ground-water flow velocity and therefore may be preferred pathways for contaminant migration. Where saturated alluvium extends beyond these paleochannels, they generally exhibit less control on directions of ground-water flow and contaminant transport. For conditions where alluvial flow is totally or largely confined to paleochannels, it is likely that the orientation and morphology of these channels

more strongly influences contaminant migration. The approximate locations of these paleochannels were discussed previously in Section 1.3 and shown in Plate 1.3-1.

Alluvial ground-water flow patterns were also considered in the design of the monitoring network. The potential alterations in the flow system in the vicinity of the boundary control systems were given particular consideration. The interpretation of the dominant flow patterns in the alluvium was discussed previously in Section 1.3. These flow patterns are depicted in Figure 1.3-3. Project area wells were selected for the network to provide both upgradient and downgradient monitoring of major potential contaminant sites and areas of degraded alluvial ground-water quality. The general wells were selected to provide representative monitoring of flow patterns on an Arsenal-wide scale.

2.2.3 Criteria Specific to the Denver Formation Monitoring Well Network Design

The Denver Formation monitoring well network was designed utilizing existing Denver Formation wells according to two classes of criteria. First, those criteria that were common to all well selections (see Section 2.2.1) and second, criteria that were specific to monitoring within the Denver. These specific criteria are listed below:

- placement of the screen interval within the Denver Formation;
- vertical contaminant distributions;
- water bearing zones within the Denver Formation;
- vertical hydraulic flow components; and
- areas of unsaturated alluvium.

Wells selected to monitor the Denver Formation were selected only from wells in which the placement of the screened interval was entirely within the Denver Formation. Wells in which the monitoring interval (well screen plus sand/filter pack) occurs only partially in the Denver Formation were not considered to be Denver Formation wells.

Water bearing zones were identified within the Denver Formation in order to assess hydraulic communication among wells. This information was used as a general indicator of preferred vertical intervals for monitoring. As more detailed geologic information is collected prior to the annual

sampling event, the Denver Formation monitoring well network will be reevaluated and modified as necessary.

Information obtained from well clusters was used to evaluate the need for monitoring various depth ranges within water-bearing zones in the Denver Formation. The vertical contaminant distributions and flow paths were evaluated for Denver and Denver/alluvial well clusters. In general, if contaminants were present in a well cluster, vertical hydraulic gradients were investigated to determine the relative importance of monitoring wells completed in zones above or below the contaminated zones. Horizontal ground-water flow directions were evaluated to provide information to assess the most appropriate locations for ground-water quality monitoring up- and downgradient of contaminated areas. These hydraulic considerations were especially important with regard to selection of project area wells.

Denver monitoring wells were also chosen to provide coverage beneath areas of unsaturated alluvium.

2.2.4 Well Selection Criteria for the Water-Level Monitoring Network

The network of wells to be used for monitoring water-level surfaces and fluctuations in the aquifers at RMA under the CMP was selected by utilizing available data to assess the usefulness of RMA wells for water-level monitoring. Data from the RMA RI/FS database were assessed for both the Denver and alluvial aquifers. Assessments considered the two aquifers individually, as will be discussed below. All wells were assessed in terms of their well construction, areal distribution, the quality of the data they would provide, and the comparability of data from each well with data from nearby wells.

Water-level data from the Spring 1987 monitoring period (Task 25 and Task 44) were used as the primary basis for the selection of wells for the CMP water-level network. Task 44 and 25 data were used because they represented the most recent period when a comprehensive list of wells were measured over the entire RMA site for which data were readily available.

2.2.4.1 Water-Level Selection Criteria for Alluvial Wells. The general philosophy of the well selections in the alluvial aquifer was to retain all wells that had been measured previously, unless a situation existed that warranted their deletion from the program. In no case was a cluster well deleted from the program because of the importance of the vertical hydraulic data cluster wells provide.

The wells that were selected for CMP water-level monitoring are the same as those measured during Task 44 with the exception of wells that were deleted for the following reasons:

1. Wells that were dry during Spring 1987, except where necessary to define the areal extent of unsaturated alluvium.

2. Wells that were identified in the construction database as being unacceptable for usage in water-level monitoring.

3. Wells that were deleted because they were in very close proximity to other wells (i.e., separated by about 500 feet or less and provided similar data).

4. Wells were sometimes deleted based on a combination of factors including areal distribution, and questionable quality of water-level data from Task 44.

If a well was located in a critical area it was retained in the network even if it had been ranked low for water quality sampling in the construction database. It should be noted that the well designation may not be as stringent for water level data as for water quality data. Specific wells in the alluvial water-level monitoring network are discussed in Section 2.3.1.

2.2.4.2 Water-Level Selection Criteria for Denver Formation Wells. The majority of the Denver Formation monitoring wells were included in the water-level monitoring network because ground-water flow patterns in the Denver Formation are considerably more complex as compared to the alluvial aquifer. Ground-water flow patterns in the Denver aquifer are difficult to assess because various vertical intervals are present under different potentiometric conditions. Until the Denver Formation aquifer zones are better defined, the data do not warrant deletions of Denver wells from the network. However, there were isolated conditions under which Denver Formation wells were deleted from the program. These included wells that were dry and wells that were identified as being of poor quality for water-level measurements and were in close proximity to other Denver Formation wells. In total, fewer than 15 wells were deleted from the Denver Formation water-level monitoring network.

2.3 Description of the CMP Ground-Water Monitoring Network

Descriptions of the alluvial, Denver Formation, and off-site ground-water monitoring well networks and a discussion of new wells are provided in Sections 2.3.1 through 2.3.4, respectively.

2.3.1 Description of Alluvial Ground-Water Monitoring Well Network

The CMP alluvial ground-water monitoring well network will be composed of general wells and specific area wells. The wells selected for each of these categories are discussed below.

2.3.1.1 General Alluvial Wells. As indicated in Section 2.1.1.1, the general wells are monitoring wells located in areas having well-defined contaminant patterns or areas where contamination has not been detected. These wells will be monitored on an annual basis to provide site-wide coverage with the sampling conducted during the fall of each year. The locations of general alluvial wells selected for regional monitoring are shown in Plate 2.3-1 (all wells outside of designated project areas). It is anticipated that any future modifications to current well selections will be made as an addendum to this technical plan. Addendums to this plan are addressed in Section 11.0.

2.3.1.2 Project Area Alluvial Wells. The rationale for selection of the project area wells was discussed in Section 2.1.1.2. These wells will be sampled semi-annually. Project area alluvial wells have been selected for the following eleven areas: the North Boundary Containment System Area, the Northwest Boundary Containment System Area, the Irondale Containment System Area, the Basin A Neck Area, the TCE Area, the Basin F Area, the South Plants Area, the North Plants Area, the Basin A Area, Sections 34 and 35 Area and the Toxic Storage Yard Area. The locations of project area alluvial wells selected for each of these areas are shown in Plate 2.3-1.

2.3.2 Description of Denver Formation Monitoring Well Network

The CMP Denver Formation ground-water monitoring network will be composed of general wells and project area wells. The wells selected for each of these categories are discussed below.

2.3.2.1 General Denver Formation Wells. As indicated for general alluvial wells in Section 2.3.1.1, the general wells are monitoring wells located in areas having well-defined contaminant patterns or areas where contamination has not been detected. These wells will be sampled on an annual basis with the sampling conducted during the fall of each year. The locations of general Denver Formation wells selected for regional monitoring are shown in Plate 2.3-2 (all wells outside of designated specific areas).

2.3.2.2 Project Area Denver Formation Wells. Project area Denver Formation wells have been selected for the following areas: North Boundary Containment System Area, Northwest Boundary Containment System Area, Irondale Containment System Area, Basin A Neck Area, South Plants Area, TCE Area, Basin F Area, Basin A Area, Sections 34 and 35 Area and the Toxic Storage Yard Area. The locations of these wells are indicated in Plate 2.3-2.

2.3.3 Description of Off-Post Monitoring Well Network

As indicated in Section 2.1.3, the off-post network is treated as a project area. Off-post wells will be subject to semi-annual monitoring. The locations of off-post alluvial wells are shown in Plate 2.3-1, and the locations of off-post Denver Formation wells are shown in Plate 2.3-2.

2.3.4 New Wells

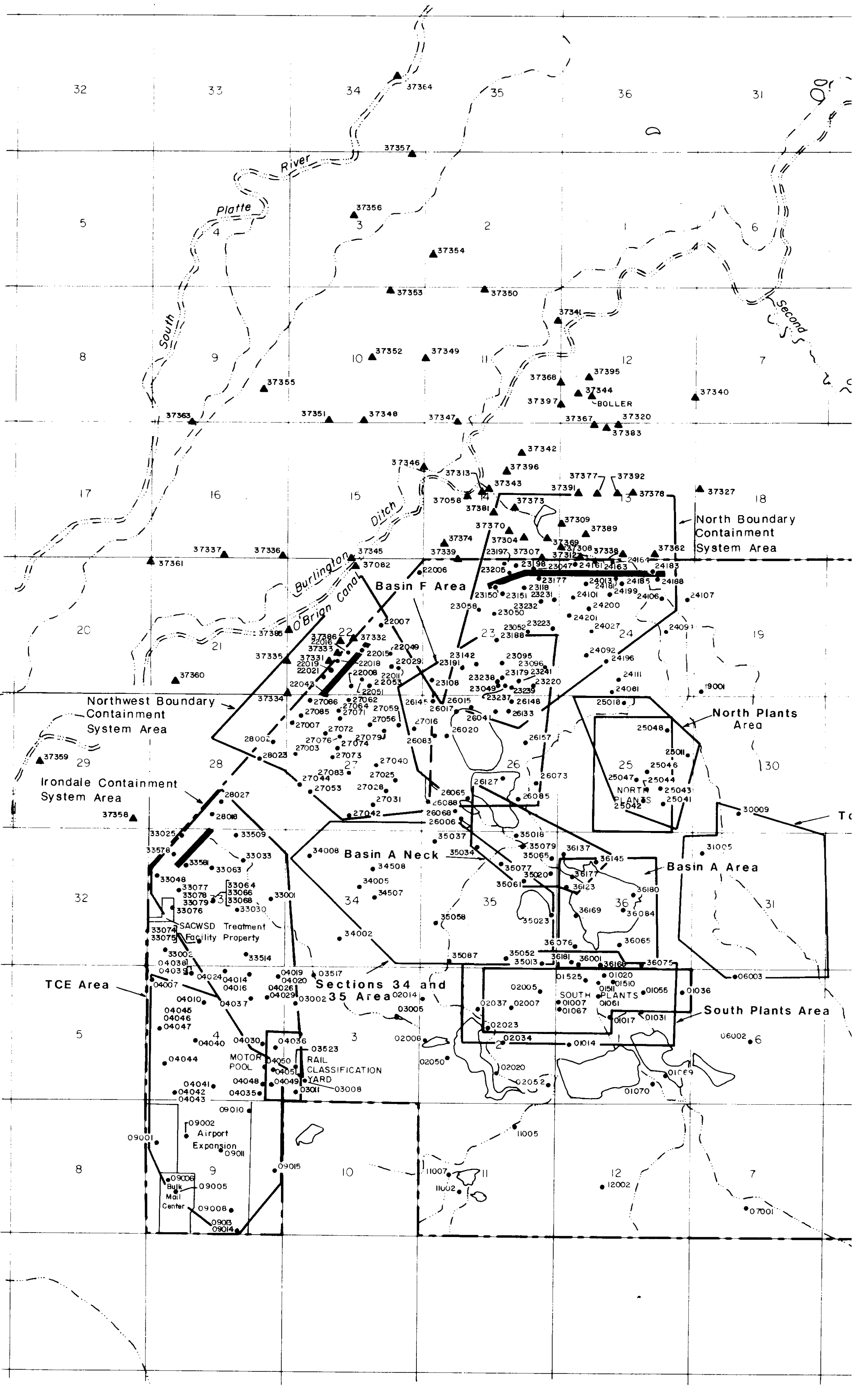
All newly installed wells will be included in the CMP ground-water monitoring network for at least two sampling periods. These wells will be sampled in conjunction with the project area sampling events. New alluvial and Denver Formation wells currently included in the network are listed in Table 2.3-1 and 2.3-2, respectively. New wells added to the CMP ground-water monitoring network will be sampled semi-annually. They will be evaluated on an annual basis to determine if they should be retained in the network.

2.3.5 Description of Water-Level Monitoring Network

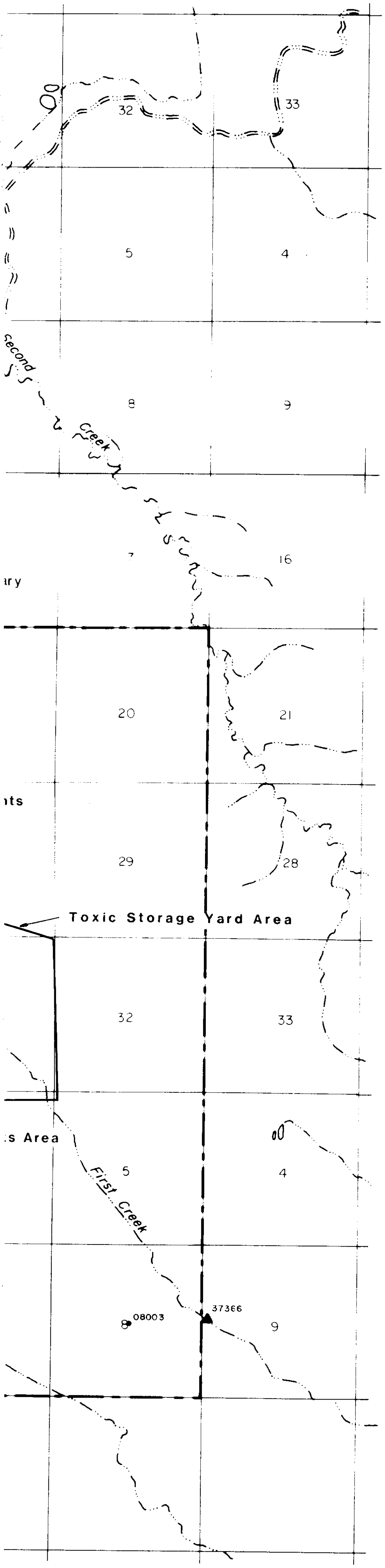
The CMP ground-water level monitoring network will be monitored on a quarterly basis. The current water level monitoring consists of 957 wells. Of the total number of wells, 524 are alluvial wells (Table 2.3-3) and 433 are Denver Formation wells (Table 2.3-4).

2.4 Sampling Frequency

The sampling frequency for general wells, and project area wells, were briefly addressed in Section 2.1. A more thorough discussion of how these sampling frequencies have been combined into sampling events is provided below. In addition, the monitoring frequency for general wells, project area wells, and water levels are illustrated in Figure 2.4-1.



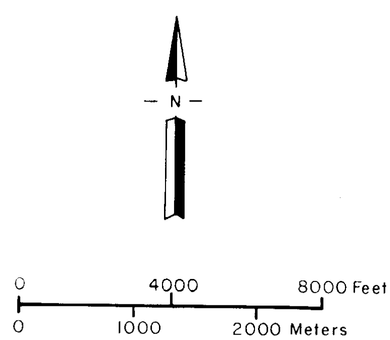
South Platte River
Burlington Ditch
O'Brien Canal
Second
Basin F Area
North Boundary Containment System Area
Northwest Boundary Containment System Area
Irondale Containment System Area
North Plants Area
NORTH PLANTS
Basin A Neck
Basin A Area
Sections 34 and 35 Area
SACWSD Treatment Facility Property
TCE Area
SOUTH PLANTS
South Plants Area
MOTOR POOL
RAIL CLASSIFICATION YARD
Airport Expansion
Bulk Mail Center
BOLLER



23150 On - Post Monitoring Well

37349 Off - Post Monitoring Well

Boundary System



Prepared for :

Program Manager's Office for
Rocky Mountain Arsenal Cleanup
Commerce City, Colorado

PLATE 2.3-1

Comprehensive Monitoring Program
Alluvial Well Network

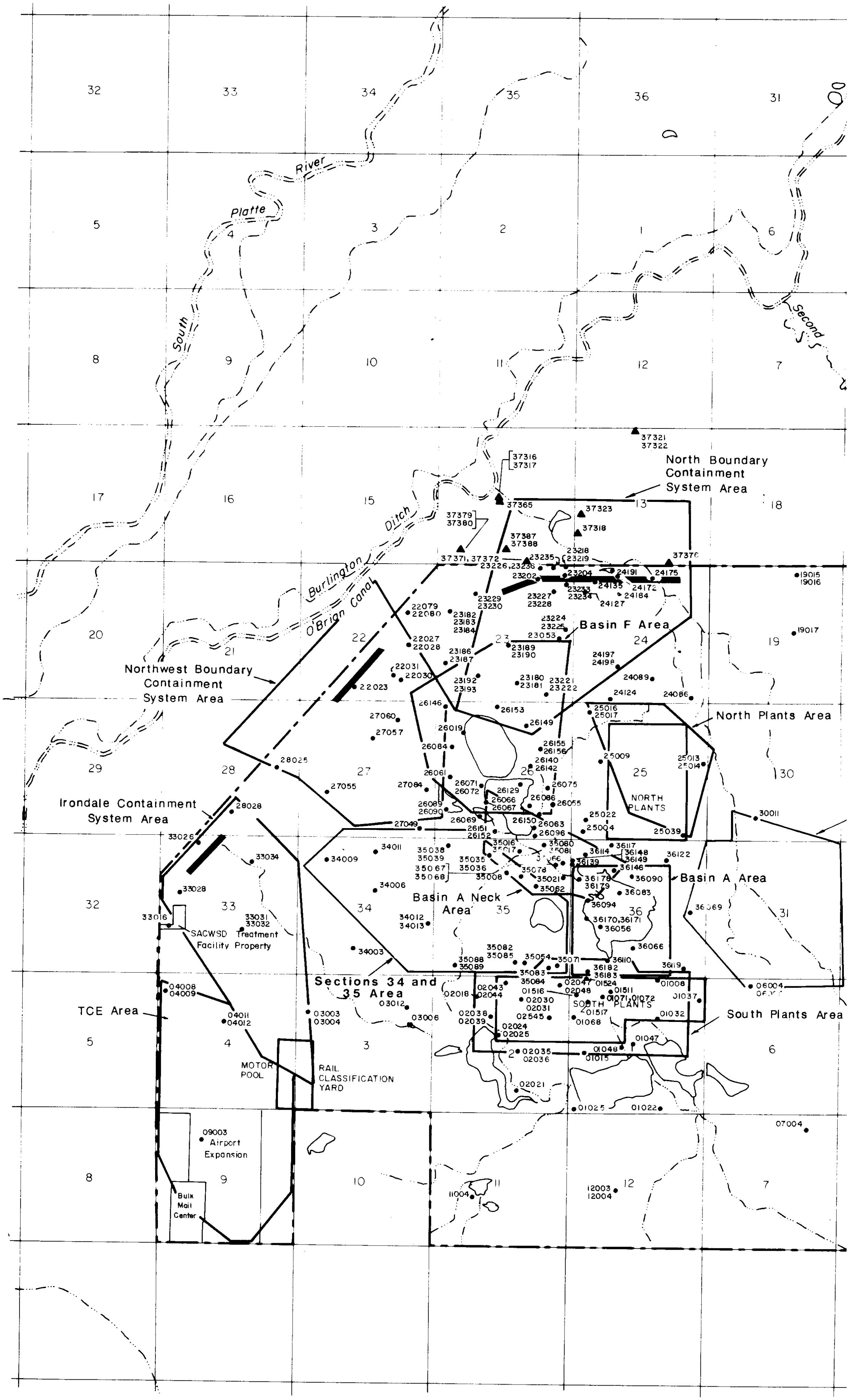
CMP Ground - Water Monitoring Technical Plan

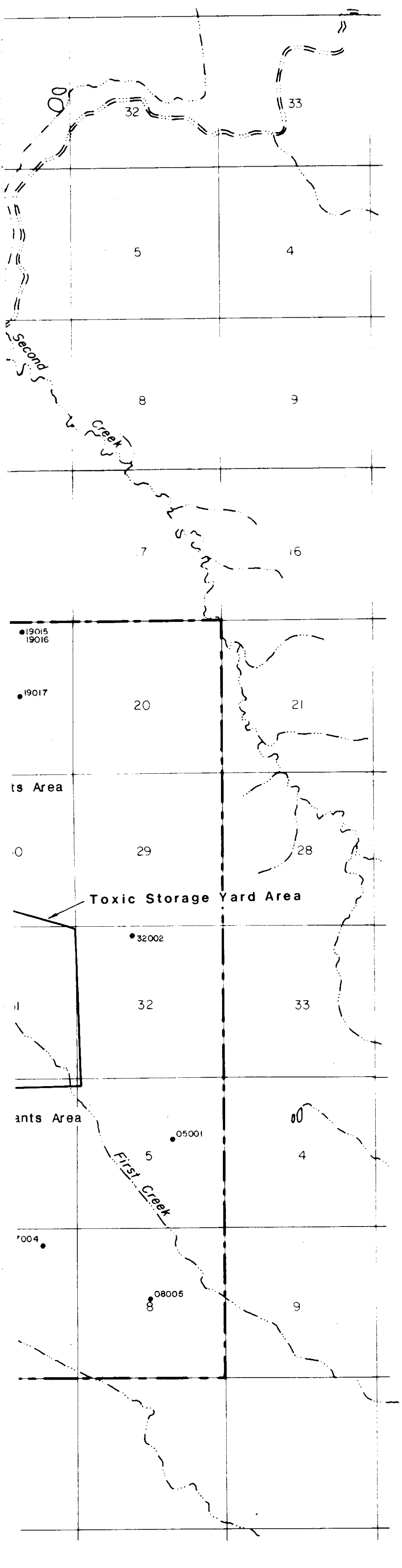
Prepared by : R.L. Stollar and Associates, Inc.
Harding Lawson Associates

Table 2.3-1 New Alluvial Monitoring Wells (Prior to FY89)

Section No.	Well No.
1	069, 070
2	050, 052
3	011
4	035, 036, 037, 038, 039, 040, 041, 042, 043, 044, 045, 046, 047, 048, 049, 050, 051
9	013, 014, 015
23	220, 223, 231, 232
24	196, 199, 200, 201
25	041, 042, 043, 044, 046, 047, 048
26	148
27	085, 086
33	074, 075, 076, 077, 078, 079
35	077, 079, 087
36	168, 169, 177, 180, 181
Off-site	367, 368, 369, 370, 373, 374, 377, 378, 381, 382, 383, 385, 386, 389, 391, 392, 395, 396, 397

Total New Alluvial Wells = 77

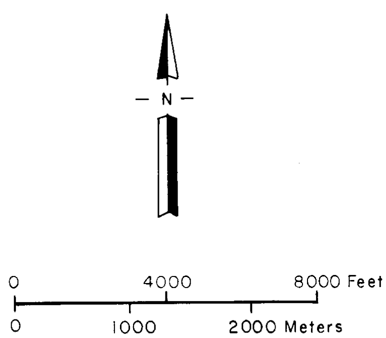

South Platte River
Burlington Ditch
O'Brian Canal
Second Creek
North Boundary Containment System Area
Northwest Boundary Containment System Area
Irondale Containment System Area
Basin F Area
North Plants Area
NORTH PLANTS
Basin A Area
Basin A Neck Area
Sections 34 and 35 Area
SOUTH PLANTS
South Plants Area
TCE Area
SACWSD Treatment Facility Property
MOTOR POOL
RAIL CLASSIFICATION YARD
Airport Expansion
Bulk Mail Center



EXPLANATION

• 34011 On - Post Monitoring Well

▲ 37321 Off - Post Monitoring Well



Prepared for :

Program Manager's Office for
Rocky Mountain Arsenal Cleanup
Commerce City, Colorado

PLATE 2.3-2
Comprehensive Monitoring Program
Denver Formation Well Network

CMP Ground - Water Monitoring Technical Plan

Prepared by : R.L. Stollar and Associates, Inc.
Harding Lawson Associates

Table 2.3-2 New Denver Formation Monitoring Wells (Prior to FY 89)

Section No.	Well No.
1	071, 072
3	012
22	079, 080
23	218, 219, 221, 222, 224, 225, 226, 227, 228, 229, 230, 233, 234, 235, 236
24	191, 197, 198
26	149, 150, 151, 152, 153, 155, 156
27	084
34	011, 012, 013
35	078, 080, 081, 082, 083, 084, 085, 088, 089
36	170, 171, 178, 179, 182, 183
Off-site	371, 372, 376, 379, 380, 387, 388, 390

Total New Denver Wells = 56

Table 2.3-3 CMP Water Level Monitoring Network

Section No.	Alluvial Wells
1	001, 004, 010, 011, 021, 024, 027, 033, 041, 044, 049, 069, 070, 501, 510, 514, 518, 528
2	001, 002, 008, 011, 014, 020, 023, 026, 034, 037, 040, 049, 050, 052, 520
3	001, 002, 005, 011, 517
4	007, 010, 013, 014, 015, 016, 017, 019, 020, 021, 022, 023, 024, 025, 026, 027, 028, 029, 035, 036, 037, 038, 039, 040, 041, 042, 043, 044, 045, 046, 047, 048, 049, 050, 051, 525
6	002, 003
7	001, 003
8	002, 003
9	002, 005, 006, 007, 008, 010, 011, 013, 014, 015
11	002, 005, 006, 007
12	001, 002, 005, 007, 008, 009
19	001, 004
22	004, 006, 008, 015, 016, 018, 019, 020, 021, 022, 033, 036, 040, 043, 049, 053, 060
23	002, 004, 007, 010, 011, 013, 016, 029, 030, 034, 036, 039, 040, 045, 046, 049, 057, 059, 072, 079, 084, 085, 092, 094, 095, 102, 108, 110, 118, 119, 120, 121, 123, 134, 135, 140, 142, 146, 150, 157, 160, 166, 178, 179, 188, 191, 196, 197, 198, 205, 207, 208, 211, 220, 223, 231, 232, 237, 238, 239, 241
24	001, 003, 004, 007, 010, 015, 016, 018, 019, 020, 021, 023, 024, 025, 027, 046, 049, 050, 051, 052 055, 056, 057, 058, 062, 064, 081, 085, 092, 093, 094, 095, 096, 097, 098, 101, 102, 103, 104, 105, 106, 111, 112, 113, 114, 117, 121, 122, 123, 128, 150, 158, 161, 162, 164, 165, 178, 179, 180, 181, 187, 188, 196, 199, 200, 201
25	001, 003, 011, 015, 018, 022, 035, 038, 041, 042, 043, 044, 046, 047, 048
26	006, 009, 010, 015, 016, 017, 020, 040, 041, 044, 046, 048, 049, 050, 062, 065, 068, 073, 076, 081, 083, 085, 088, 091, 093, 124, 126, 127, 133, 143, 145, 148, 157

Table 2.3-3 (cont'd.)

Section No.	Alluvial Wells
27	002, 003, 004, 005, 006, 007, 009, 010, 011, 016, 018, 025, 031, 037, 040, 041, 042, 043, 044, 045, 051, 053, 062, 063, 064, 066, 068, 070, 071, 072, 074, 075, 077, 080, 081, 082, 083, 085, 086
28	003, 006, 008, 012, 014, 018, 020, 021, 022, 023, 024, 027, 503, 513
30	002, 009
31	003, 005, 009
32	001
33	001, 002, 014, 017, 018, 019, 020, 021, 022, 023, 024, 025, 030, 033, 048, 049, 050, 053, 054, 060, 061, 062, 063, 064, 065, 066, 067, 068, 069, 070, 071, 072, 073, 074, 075, 076, 077, 078, 079, 500, 501, 502, 505, 507, 509, 510, 512, 576, 577, 579, 580, 581, 582, 583
34	001, 002, 005, 008, 515
35	007, 023, 025, 040, 047, 048, 052, 053, 058, 061, 065, 069, 077, 079, 087
36	013, 017, 050, 060, 063, 065, 067, 073, 075, 076, 077, 081, 082, 084, 085, 087, 089, 093, 109, 112, 137, 141, 142, 145, 163, 164, 165, 166, 167, 168, 169, 177, 180, 181
Off-Site	37058, 37304, 37307, 37308, 37309, 37312, 37313, 37320, 37327, 37330, 37331, 37332, 37333, 37334, 37335, 37336, 37337, 37338, 37339, 37340, 37341, 37342, 37343, 37344, 37345, 37346, 37347, 37348, 37349, 37350, 37351, 37352, 37353, 37354, 37355, 37356, 37357, 37358, 37359, 37360, 37361, 37362, 37363, 37364, 37366, 37367, 37369, 37370, 37373, 37374, 37377, 37378, 37381, 37382, 37383, 37385, 37386, 37389, 37391, 37392, 37395, 37396, 37397

Total Alluvial Wells = 524

Table 2.3-4 CMP Water Level Monitoring Network

Section No.	Denver Formation Wells
1	007, 008, 012, 014, 015, 016, 018, 019, 022, 023, 025, 028, 029, 030, 031, 032, 034, 035, 036, 037, 039, 040, 042, 043, 045, 046, 047, 048, 050, 071, 072, 522, 534, 537, 554, 568, 586, 588
2	003, 004, 005, 006, 007, 009, 010, 012, 013, 015, 016, 018, 019, 021, 022, 024, 025, 027, 028, 030, 031, 032, 033, 035, 036, 038, 039, 041, 042, 043, 044, 045, 046, 047, 048, 545, 578, 580, 583, 585
3	003, 004, 006, 007, 012
4	008, 009, 011, 012
5	001, 002, 003
6	004, 005
7	004, 005
8	003, 004
9	003, 004
11	003, 004
12	003, 004
19	002, 003, 005, 006, 007, 011, 015, 016, 017, 018, 019
22	002, 023, 024, 027, 028, 030, 031, 079, 080
23	053, 054, 055, 106, 125, 144, 161, 176, 177, 180, 181, 182, 183, 184, 185, 186, 187, 189, 190, 192, 193, 199, 200, 201, 202, 203, 204, 209, 218, 219, 221, 222, 224, 225, 226, 227, 228, 229, 230, 233, 234, 235, 236
24	063, 080, 082, 083, 086, 087, 089, 108, 109, 120, 124, 125, 126, 127, 130, 135, 136, 137, 159, 167, 168, 171, 172, 174, 175, 184, 191, 197, 198

Table 2.3-4 (cont'd.)

Section No.	Denver Formation Wells
25	004, 007, 008, 009, 010, 012, 013, 014, 016, 017, 019, 020, 021, 023, 024, 026, 028, 029, 031, 033, 034, 037, 039, 040
26	019, 022, 023, 024, 025, 026, 027, 028, 029, 041, 043, 047, 051, 052, 053, 054, 055, 056, 057, 058, 060, 061, 063, 064, 066, 067, 069, 071, 072, 074, 075, 077, 079, 080, 082, 084, 086, 089, 090, 092, 094, 096, 097, 123, 128, 129, 130, 134, 135, 136, 140, 141, 142, 144, 146, 147, 149, 150, 151, 152, 153, 155, 156
27	049, 054, 055, 057, 058, 084
28	025, 026, 028, 029
29	002, 003
30	004, 005, 006, 007, 008, 010, 011
31	002, 006, 007, 008, 010, 011
32	002, 003
33	015, 016, 026, 027, 028, 029, 031, 032, 034, 035
34	003, 004, 006, 007, 009, 010, 011, 012, 013
35	005, 008, 009, 012, 013, 014, 015, 016, 017, 024, 027, 028, 030, 032, 033, 036, 038, 039, 041, 050, 051, 054, 055, 056, 059, 062, 063, 066, 067, 068, 070, 071, 073, 074, 078, 080, 081, 082, 083, 084, 085, 088, 089
36	010, 024, 029, 036, 043, 047, 056, 057, 061, 062, 066, 068, 069, 072, 078, 079, 083, 086, 090, 092, 099, 104, 105, 110, 113, 114, 117, 118, 119, 121, 122, 138, 139, 140, 146, 147, 170, 171, 178, 179, 182, 183
Off-site	37316, 37317, 37318, 37319, 37321, 37322, 37323, 37365, 37371, 37372, 37376, 37379, 37380, 37387, 37388, 37390

Total Denver Wells = 433

2.4.1 Annual Sampling Event

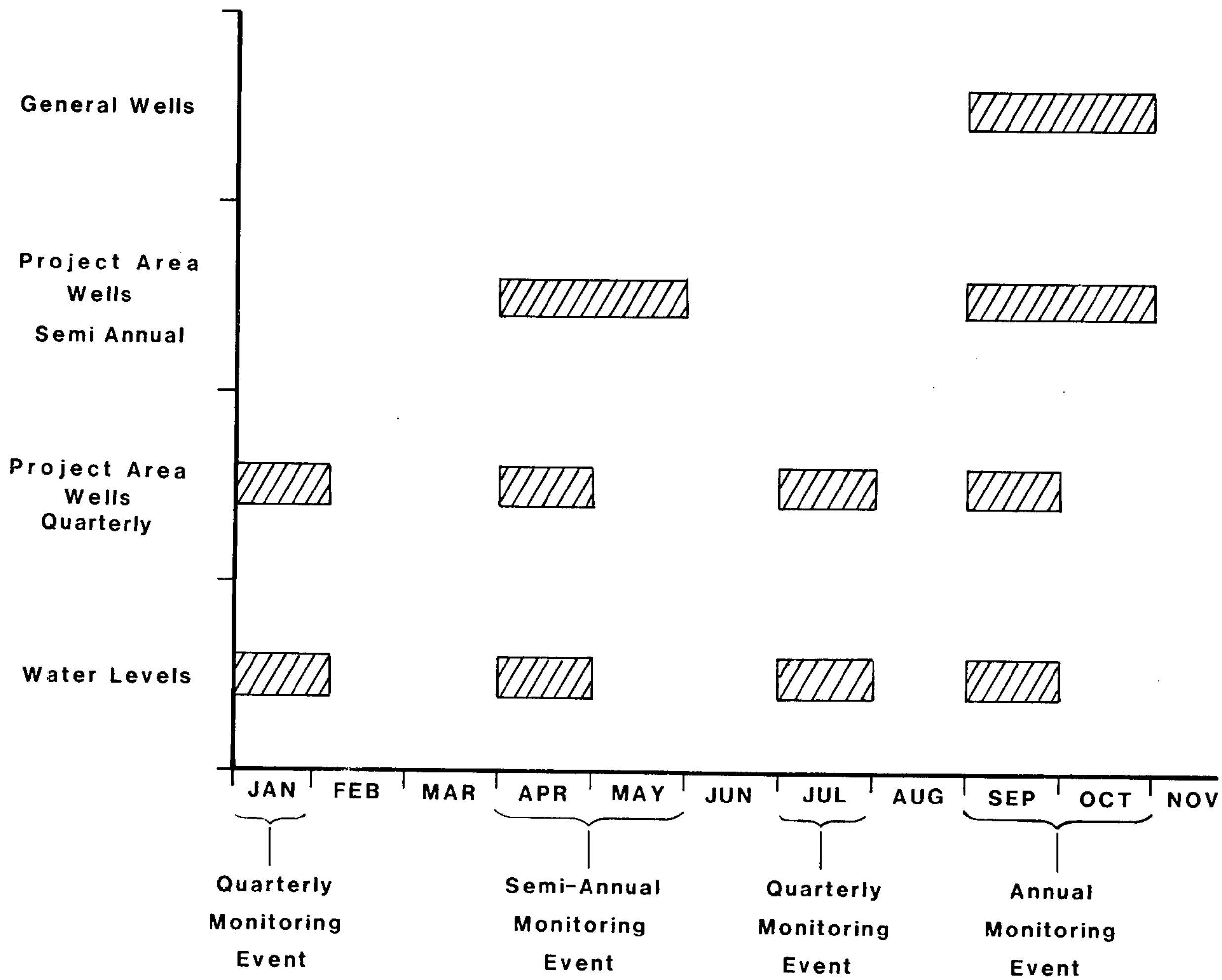
The annual sampling event will be performed during the Fall (September, October, and November) of each year. The general wells will be sampled during the annual sampling event (once per year). In conjunction with the annual sampling event, the following monitoring wells will also be sampled: the project area wells (which are to be sampled twice per year), and any new wells. In addition, a quarterly water-level monitoring event will be conducted in conjunction with the annual sampling event. The alluvial and Denver Formation wells to be sampled during the semi-annual sampling event are listed in Table 2.4-1.

2.4.2 Semi-Annual Sampling Event

The semi-annual sampling event will be conducted in the spring of each year and in the fall in conjunction with the annual sampling event. Project area wells, and new wells will be sampled during this event. In addition, the quarterly water-level monitoring event will take place in conjunction with this sampling event. The alluvial and Denver Formation wells to be sampled semi-annually are listed in Table 2.4-2.

2.4.3 Quarterly Sampling Event

The wells sampled during the quarterly sampling events will provide data in support of projects in specific areas. The Basin F area is currently the primary project area. Other project area wells may be monitored on a quarterly basis where increased monitoring is justified by a change in conditions or the need to collect additional data in support of interim actions and/or final remedial measures. Water-level measurements will also be conducted in conjunction with each of the quarterly monitoring events. The Basin F area alluvial and Denver Formation wells to be sampled on a quarterly basis are listed in Table 2.4-3.



Prepared for:

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Rocky Mountain Arsenal Cleanup
Commerce City, Colorado

5/17/88

FIGURE 2.4-1

Relationships Between Sampling Frequency and Monitoring Event for the Comprehensive Monitoring Program

CMP Ground-Water Monitoring Technical Plan

Prepared by: R.L. Stollar and Associates, Inc.

Table 2.4-1 Wells to be Sampled During CMP Annual Monitoring Event

Section No.	Total Wells	Alluvial Wells
01	14	007, 014*, 017, 020, 031*, 036, 055, 061, 067, 069, 070, 510*, 511, 525*
02	10	005*, 007, 008, 014, 020, 023, 034, 037, 050, 052
03	6	002*, 005*, 008, 011, 517, 523*
04	27	007, 010, 014*, 016, 019, 020, 024, 026*, 029, 030, 035, 036, 037, 038, 039, 040, 041, 042, 043, 044, 045, 046, 047, 048, 049, 050, 051
06	2	002, 003
07	1	001
08	1	003
09	8	001, 002, 005, 008, 010*, 013, 014, 015
11	3	002, 005, 007
12	1	002
19	3	001, 006, 011
22	14	006*, 007, 008, 011, 015, 016, 018, 019, 021*, 029, 043, 049, 051, 053
23	27	047, 049, 050, 052, 058, 095*, 096, 108, 118, 142, 150, 151, 177, 179*, 188*, 191, 197, 198, 205, 220, 223, 231*, 232, 237, 238, 239, 241
24	20	013, 027, 081, 092*, 094, 101, 106, 107, 111, 161, 163, 164, 181, 183, 185, 188*, 196, 199, 200, 201
25	9	011, 018, 041, 042, 043, 044, 046, 047, 048
26	16	006, 015, 017, 020, 041*, 065, 068, 073, 083, 085, 088, 127*, 133*, 145, 148, 157
27	23	003, 007, 016, 025, 028*, 031, 040, 042, 044, 053, 056, 059, 062, 064, 071, 072, 073, 074, 076, 079, 083, 085, 086
28	4	002, 018, 023*, 027

Table 2.4-1 (cont'd.)

Section No.	Total Wells	Alluvial Wells (continued)
30	1	009
31	1	005
33	20	001, 002, 025, 030, 033, 048, 063, 064, 066*, 068, 074, 075, 076, 077, 078, 079, 509, 514, 578, 581
34	5	002, 005*, 008*, 507, 508
35	13	013, 018*, 020, 023, 034, 037, 052, 058, 061, 065*, 077, 079, 087
36	13	001*, 065, 075, 076*, 084, 123, 137, 145, 168, 169, 177, 180*, 181
Offpost	64	37058, 37082, 37304, 37307*, 37308, 37309, 37312*, 37313, 37320, 37327, 37331*, 37332, 37333, 37334, 37335, 37336*, 37337, 37338, 37339, 37340, 37341*, 37342, 37343, 37344, 37345*, 37346, 37347, 37348, 37349*, 37350, 37351, 37352, 37353, 37354*, 37355, 37356, 37357, 37358, 37359*, 37360, 37361, 37362, 37363*, 37364, 37366, 37367, 37368*, 37369, 37370, 37373, 37374, 37377, 37378*, 37381, 37383, 37385, 37386, 37389, 37391*, 37392, 37395, 37396, 37397, Boller

Total Alluvial Wells = 306

Section No.	Total Wells	Denver Wells
01	14	008, 015*, 022, 025, 032*, 037, 047, 048, 068, 071*, 072, 516, 517, 524
02	15	018, 021*, 024, 025, 030, 031*, 035, 036, 038, 039*, 043, 044, 047, 048*, 545
03	4	003*, 004, 006, 012
04	4	008, 009*, 011, 012
05	1	001
06	2	004*, 005

Table 2.4-1 (cont'd.)

Section No.	Total Wells	Denver Wells (continued)
07	1	004
08	1	005
09	1	003*
11	1	004
12	2	003*, 004
19	3	015, 016, 017
22	7	023, 027*, 028, 030, 031, 079, 080*
23	29	053, 180, 181, 182*, 183, 184, 186, 187, 189*, 190, 192, 193, 202, 204*, 218, 219, 221, 222*, 224, 225, 226, 227, 228*, 229, 230, 233, 234, 235, 236*
24	11	086*, 089, 124, 127, 135*, 172, 175, 184, 191, 197, 198*
25	8	004, 009, 013*, 014, 016*, 017, 022, 039
26	26	019*, 055, 061, 063, 066*, 067, 069, 071*, 072, 075, 084, 086, 089, 090, 096, 129, 140, 142*, 146, 149, 150, 151, 152, 153*, 155, 156
27	5	049, 055, 057*, 060, 084
28	2	025*, 028
30	1	011
32	1	002
33	6	016, 026, 028, 031, 032*, 034
34	6	003, 006*, 009*, 011, 012, 013
35	23	008, 016, 017, 021, 035*, 036, 038, 039, 054, 062, 066*, 067, 068, 071, 078, 080, 081, 082, 083, 084, 085, 088, 089

Table 2.4-1 (cont'd.)

Section No.	Total Wells	Denver Wells (continued)
36	21	056, 066, 069*, 083, 090, 094, 110*, 114, 117, 119, 122, 139*, 146, 148, 149, 170, 171, 178, 179, 182, 183*
Offpost	14	37316, 37317*, 37318, 37321, 37322, 37323*, 37365, 37371, 37372, 37376, 37379, 37380, 37387, 37388*

Total Denver Wells = 209

* Indicates wells for which GC/MS analysis will be conducted.

Table 2.4-2 Wells to be Sampled During CMP Semi-Annual Monitoring Events

Section No.	Total Wells	Alluvial Wells
01	12	007, 014, 017, 020, 031, 055, 061, 067, 069, 070, 510, 525
02	7	005, 007, 023, 034, 037, 050, 052
03	4	002, 011, 517, 523
04	27	007, 010, 014, 016, 019, 020, 024, 026, 029, 030, 035, 036, 037, 038, 039, 040, 041, 042, 043, 044, 045, 046, 047, 048, 049, 050, 051
09	8	001, 002, 005, 008, 010, 013, 014, 015
22	6	007, 008, 015, 021, 029, 053
23	19	049, 095, 108, 142, 150, 151, 177, 179, 188, 191, 198, 220, 223, 231, 232, 237, 238, 239, 241
24	11	013, 092, 106, 161, 183, 185, 188, 196, 199, 200, 201
25	7	041, 042, 043, 044, 046, 047, 048
26	14	015, 017, 020, 041, 065, 073, 083, 085, 088, 127, 133, 145, 148, 157
27	15	007, 016, 025, 028, 031, 042, 044, 053, 056, 059, 071, 072, 074, 085, 086
28	4	002, 018, 023, 027
33	18	001, 025, 033, 048, 063, 064, 066, 068, 074, 075, 076, 077, 078, 079, 509, 514, 578, 581
35	9	013, 018, 020, 034, 061, 065, 077, 079, 087
36	10	001, 075, 123, 137, 145, 168, 169, 177, 180, 181
Offpost	64	37058, 37082, 37304, 37307, 37308, 37309, 37312, 37313, 37320, 37327, 37331, 37332, 37333, 37334, 37335, 37336, 37337, 37338, 37339, 37340, 37341, 37342, 37343, 37344, 37345, 37346, 37347, 37348, 37349, 37350, 37351, 37352, 37353, 37354, 37355, 37356, 37357, 37358, 37359, 37360, 37361, 37362, 37363, 37364, 37366, 37367, 37368, 37369, 37370, 37373, 37374, 37377, 37378, 37381, 37383, 37385, 37386, 37389, 37391, 37392, 37395, 37396, 37397, Boller

Total Alluvial Wells = 235

Table 2.4-2 (cont'd.)

Section No.	Total Wells	Denver Wells
01	6	015, 032, 047, 068, 071, 072
02	12	024, 025, 030, 031, 035, 036, 038, 039, 043, 044, 047, 048
03	3	003, 004, 012
04	2	011, 012
22	6	023, 027, 028, 030, 079, 080
23	23	180, 181, 189, 190, 192, 193, 202, 204, 218, 219, 221, 222, 224, 225, 226, 227, 228, 229, 230, 233, 234, 235, 236
24	6	135, 136, 175, 191, 197, 198
25	2	004, 022
26	25	019, 055, 063, 066, 067, 069, 071, 072, 075, 084, 086, 089, 090, 096, 129, 140, 142, 146, 149, 150, 151, 152, 153, 155, 156
27	4	055, 057, 060, 084
28	2	025, 028
33	5	026, 028, 031, 032, 034
34	3	011, 012, 013
35	18	008, 016, 017, 021, 035, 036, 062, 066, 071, 078, 080, 081, 082, 083, 084, 085, 088, 089
36	10	094, 114, 139, 146, 170, 171, 178, 179, 182, 183
Offpost	14	37316, 37317, 37318, 37321, 37322, 37323, 37365, 37371, 37372, 37376, 37379, 37380, 37387, 37388

Total Denver Wells = 141

Table 2.4-3 Wells to be Sampled During CMP Quarterly Monitoring Events

Section No.	Total Wells	Alluvial Wells
23	12	049, 095, 108, 142, 179, 188, 191, 220, 237, 238, 239, 241
26	13	015, 017, 020, 041, 065, 073, 083, 085, 127, 133, 145, 148, 157
27	1	016

Total Alluvial Wells = 26

Section No.	Total Wells	Denver Wells
23	8	180, 181, 189, 190, 192, 193, 221, 222
26	17	019, 066, 067, 071, 072, 075, 084, 086, 129, 140, 142, 146, 149, 150, 153, 155, 156

Total Denver Wells = 25

3.0 LABORATORY ANALYSIS PROGRAM

The objective of the laboratory analysis program is to provide the PM RMA with reliable, and legally defensible ground-water quality data for RMA. The analytical program requires that collected ground-water samples be analyzed for a selected list of chemical parameters to achieve a quantitative determination of water quality as described in Section 3.1. The analytical program also includes semi-quantitative analysis of selected samples as discussed in Section 3.2.

3.1 Analytical Parameters

The ground-water samples which will be collected during the sampling events outlined in this Technical Plan will be analyzed for parameters listed in Table 3.1-1. The list of analytical parameters to be used will be a continuation of the list developed under Task 44 of the RI/FS with the addition of benzothiazole, parathion, cyanide, and acid extractables. This list may be modified for future sampling events based upon interpretation of data collected during the RI/FS and evaluation of the results of the CMP monitoring events and an evaluation of the results of previous Gas Chromatography-Mass Spectroscopy (GC/MS) analysis of nontarget analytes. The methodologies and detection limits for analysis of the target analytes are as specified by USATHAMA. Specific analytical methods are discussed in detail in the CMP Analytical Procedures Manual.

The defensibility and technical quality of data generated in this program will be assured by documenting all of the analytical procedures and requiring all data to exceed minimum analysis method requirements with respect to instrument calibration. Sample preparation, materials shipping, handling, and chain-of-custody procedures will follow the protocol outlined in the Quality Assurance/Quality Control Manual for the Comprehensive Monitoring Program.

3.2 GC/MS Analysis

The laboratory analysis program will include a semi-quantitative analysis of selected ground-water samples by the GC/MS analytical technique. This technique will provide confirmation of target analytes that can be detected by gas chromatography (GC). In addition, the GC/MS analysis will be used to indicate the presence of nontarget analytes. Consistent with prior practice, where nontarget analytes are repeatedly detected at elevated levels, action will be taken to identify the compounds and evaluate them for incorporation into the target analyte parameters.

Table 3.1-1 Analytical Parameters

Organochlorine Pesticide Method

- Aldrin
- Endrin
- Dieldrin
- Isodrin
- Hexachlorocyclopentadiene
- p,p'-DDE
- p,p'-DDT

Volatile Organohalogen Method

- Chlorobenzene
- Chloroform
- Carbon Tetrachloride
- trans-1,2-Dichloroethylene
- Trichloroethylene
- 1,1 Dichloroethylene
- 1,1 Dichloroethane
- 1,2 Dichloroethane
- 1,1,1 Trichloroethane
- 1,1,2 Trichloroethane
- Methylene Chloride
- Tetrachloroethylene

Organosulfur Compound Method

- P-Chlorophenylmethylsulfone
- P-Chlorophenylmethylsulfoxide
- P-Chlorophenylmethylsulfide
- 1,4-Dithiane
- 1,4-Oxithiane
- Dimethyldisulfide
- Benzothiazole

Organophosphorus Compound Method

- Parathion

Volatile Aromatic Method

- Toluene
- Benzene
- Xylene (m-)
- Ethylbenzene
- Xylene (o,p)

DCPD/MIBK Method

- Dicyclopentadiene
- Methylisobutyl Ketone

Phosphonate Method

- Diisopropylmethylphosphonate (DIMP)
- Dimethylmethylphosphonate (DMMP)

DBCP Method

- Dibromochloropropane

Metals

- Mercury
- Arsenic
- Cadium
- Chromium
- Copper
- Lead
- Zinc

Cations

- Potassium
- Calcium
- Magnesium
- Sodium

Anions

- Chloride
- Fluoride
- Sulfate
- Nitrate+Nitrite
- Alkalinity (as $CaCO_3$)

Acid Extractables

- Phenols (EPA Method 8270)

Cyanide Method

- Cyanide

GC/MS (20% of wells sampled annually)

- Base
- Neutral
- Acid

Gas Chromotography and Mass Spectroscopy analysis will be performed on approximately 20 percent of the samples collected from either the annual (Fall) or the semi-annual (Spring) sampling events. The wells for which samples will be analyzed using GC/MS are indicated by an asterisk in Table 2.4-1. As data for each year are evaluated the wells to be analyzed using GC/MS may change for subsequent sampling events.

4.0 GEOTECHNICAL PROGRAM

The geotechnical program for the CMP will consist of maintenance of existing monitoring wells, replacement of existing wells that have been destroyed, and installation of new monitoring wells if required.

4.1 Maintenance of Existing Monitoring Wells

The need for maintenance activities will be evaluated after each sampling event. Maintenance activities identified will be performed prior to the succeeding sampling event. If monitoring well maintenance is required it will be limited to the following maintenance activities:

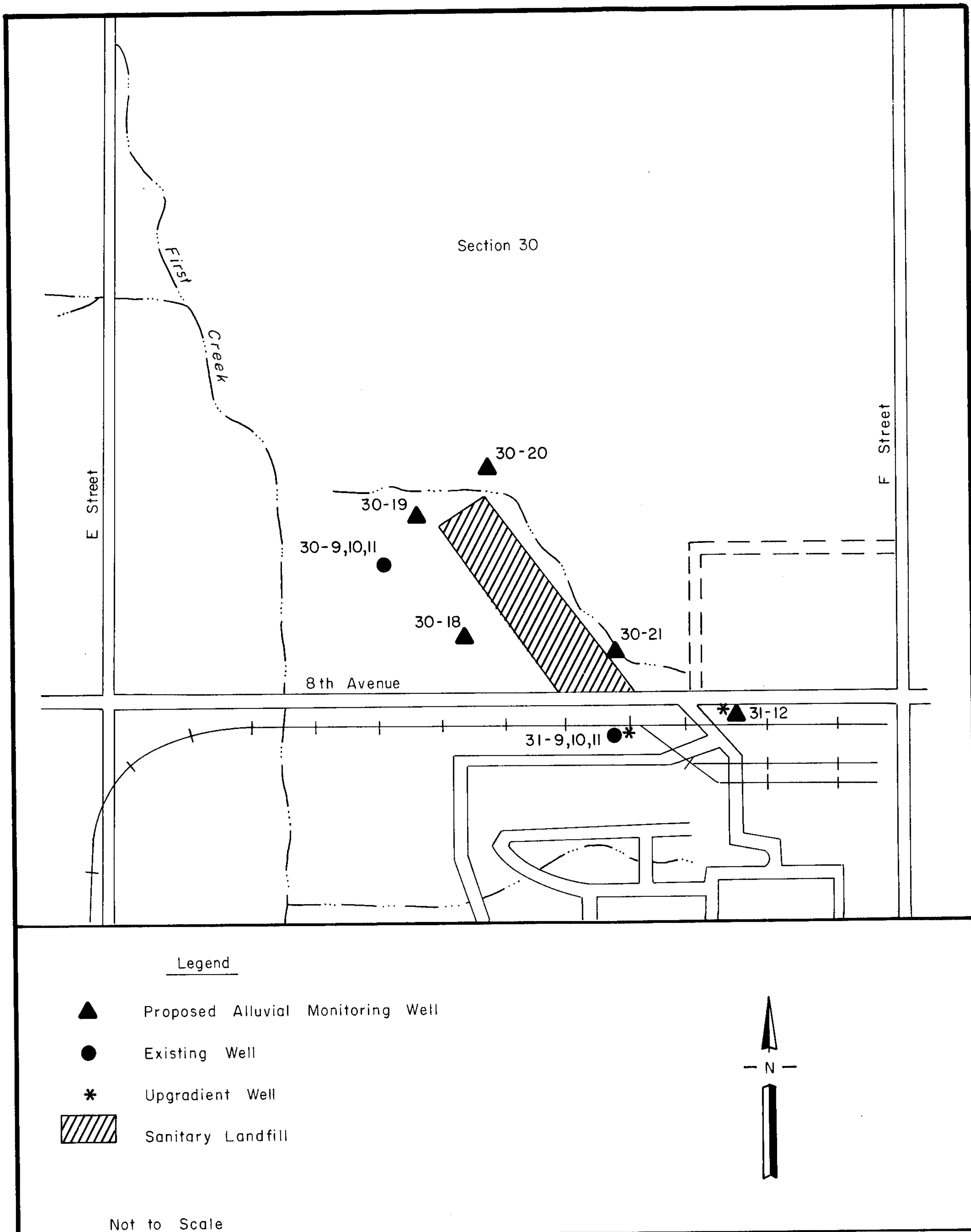
- repair of casing stickups;
- installation of protector casings;
- installation of steel marker posts;
- installation of surface seals;
- resurvey of repaired well sites;
- installation of permanent identification tags;
- installation of replacement well caps;
- clearance of weeds from area around wells;
- installation of weed barrier mats;
- redevelopment of monitoring wells; and
- removal of accumulated sediment in well casing.

4.2 Installation of New Monitoring Wells

It may be necessary to install a limited number of new wells under the Comprehensive Monitoring Program. The need for new well installations will be identified after evaluation of the results of each monitoring event. New well installations that may be identified as a result of the evaluation will be added to this Technical Plan as an addendum.

A need for five new monitoring wells has been identified in the Ground-Water Monitoring Plan for the RMA sanitary landfill (U.S. Army EHA, 1987). At the direction of the PM RMA, ground-water monitoring wells specified in this Plan will be installed under the CMP. The existing well configuration around the sanitary landfill in Section 30 requires upgrading for the purposes of monitoring for chemical constituents. The design of the existing wells did not meet current acceptable specifications applicable to ground-water monitoring. The proposed ground-water monitoring

plan involves the installation of five new alluvial monitoring wells as indicated in Figure 4.2-1. These wells will be installed according to the well installation procedures specified in the CMP Field Procedures Manual and will be sampled semi-annually until a representative database for these wells is established.



Prepared for :

Program Manager's Office for

Rocky Mountain Arsenal Cleanup

Commerce City, Colorado

Drafted 4/28/88

FIGURE 4.2-1

Proposed Alluvial Monitoring Wells to be Installed for the RMA Ground-Water Monitoring Program

CMP Ground-Water Monitoring Technical Plan

Prepared by : R.L. Stollar and Associates, Inc.

5.0 REPORTING AND DATA ASSESSMENT

The purpose of the ground-water monitoring element of the CMP is to maintain the water-quality and water-level database and allow verification of contaminant pathways and hydraulic conditions in the alluvial and Denver Formation aquifers on RMA and in designated off-post areas. As specified in the introduction to this Technical Plan, the objectives of the program are to:

1. Monitor ground-water quality and ground-water hydrology to assess changes in the rate and extent of contamination and distribution of contaminant patterns in both on-post and off-post areas.

2. Maintain a regional ground-water monitoring program for regulatory database maintenance and RI/FS verification purposes.

3. Maintain project area ground-water monitoring programs for regulatory database maintenance, RI/FS verification, and system operational purposes.

In order to meet these objectives, it will be necessary to compile and evaluate the information generated during the CMP and previous monitoring programs. A data assessment will be completed in order to evaluate relationships between ground-water plumes and sources of contamination on RMA, the ground-water quality on and downgradient of RMA, and contaminant pathways.

Information generated by the CMP Ground-Water Element will be presented in an annual technical report. This report will include:

- a summary of background information;
- discussions of all work performed during the previous year;
- compilation of field, laboratory, and office data developed under the program;
- the results of interpretive efforts;
- conclusions drawn during the program;
- recommendations for program changes for succeeding monitoring events;
- recommended modifications to the monitoring system; and
- recommended changes in the operation or monitoring of specific remedial actions.

A more detailed discussion of the contents of the Technical Report is presented in the following sections.

5.1 Presentation of Ground-Water Data

Both tabular and graphical presentations of ground-water data will be provided. Tabular presentations will, at a minimum, include:

- a summary of water levels for all wells monitored by monitoring event;
- a summary of ground-water chemistry by sampling event; and
- boring logs and well completion details, if applicable.

Graphical presentations will, at a minimum, include:

- water level contour maps for each aquifer, where appropriate;
- contaminant distribution or plume maps, where possible, for each target analyte or for analyte groups for both the alluvial and Denver Formation aquifers;
- revised geologic maps based on additional geologic data; and
- maps indicating any revisions in areas of unsaturated alluvium and the extent of inferred paleochannels, if necessary.

5.2 Hydrogeologic Analysis

A section of the annual CMP report will address the hydrogeologic analysis. This section will, at a minimum, include:

- The results of all ground-water level monitoring conducted during the past year.
- A comparison of water-level monitoring data obtained during the CMP to monitoring data acquired during previous investigations. This analysis will include development of well and section hydrographs and identification of areas having significant ground-water fluctuations.

- A discussion of any recommended modifications to the water level monitoring program.

- Stratigraphic/hydrogeologic evaluation of the alluvium and Denver Formation to identify geometry, extent, and potential for hydraulic interaction between aquifers and a comparison to the results of evaluations from previous investigations.

5.3 Contamination Assessment

The objective of contamination assessment will be to assess the rate of movement and extent of contamination in the ground water on RMA and in designated off-post areas, to evaluate general relationships between ground-water quality and sources of contamination on RMA, and to assess changes in contaminant migration pathways.

The assessment will include at a minimum:

- compilation and evaluation of all ground-water quality data obtained during the past year including a statistical evaluation where possible to identify significant trends;

- assessment of any changes in water quantity or quality from monitoring conducted during previous investigations;

- an evaluation of the levels of contamination in both the Denver and alluvial aquifers;

- assessment of any changes in contaminant plumes and contaminant migration pathways;

- a discussion of any recommended alterations in sampling locations, frequency, analytical parameters, equipment, methodology, and the need for other future out-of-scope activities;

- recommendations for new monitoring wells; and

- ground-water/surface-water interactions.

6.0 PROCEDURES

Specific ground-water sampling procedures are consistent with the methods outlined in the EPA field methods manual (U.S. Environmental Protection Agency, 1986) and are presently being conducted under the RI/FS programs. Laboratory procedures are discussed in the CMP Analytical Methods Manual, Sample handling and chain-of-custody procedures are discussed in detail in the CMP Quality Assurance/Quality Control Plan.

7.0 QUALITY ASSURANCE

7.1 Field/Laboratory QA Program

The Quality Assurance (QA) program for ground-water monitoring, sampling, and analysis will be consistent with the QA Plan developed for the Comprehensive Monitoring Program. As designed, the QA Plan will ensure that valid and properly formatted data will be reported at the appropriate precision, accuracy, and sensitivity of each method used for PM RMA USATHAMA sampling and analysis efforts. The plan is based on PM RMA USATHAMA December 1985 QA program, second edition requirements, as well as certified analytical methods submitted to and approved by PM RMA USATHAMA. Specific RMA QA/QC requirements for the ground-water program are contained in the Quality Assurance/Quality Control Plan.

7.2 Specific RMA-CMP Requirements

7.2.1 QA/QC Responsibilities

QA/QC responsibilities are discussed in detail in the Quality Assurance/Quality Control Plan.

7.2.2 Field Procedures

The Field QA Coordinator will report any discrepancies that cannot be resolved on-site to the Project QA Coordinator. Field sampling QA audits of the ground-water monitoring and sampling procedures for the Comprehensive Monitoring Program will be conducted by the Field QA Coordinator every six to eight weeks. Samples must be collected in properly cleaned containers, promptly and properly preserved, and transported to the laboratory. The Comprehensive Monitoring Program QA/QC Plan describes the field procedures to monitor adherence to approved sampling QC practices.

Field operations to be audited include: (1) sample collection, (2) sample handling, (3) use of sample containers or collectors for the particular analysis, and (4) field documentation and chain-of-custody practices. To ensure that no contamination is introduced during the collection or transportation of the samples, field and trip blanks will be introduced into the sampling train. These blanks will be prepared in the laboratory using deionized water and sent to the field. Field QA blanks will be uncapped in the field during sampling to monitor potential contamination during the sampling process. Trip blanks will be carried with the samples during transport to monitor potential contamination during transport and shipment of the samples. To ensure that no

contamination is introduced as a result of improper equipment decontamination, equipment rinse blanks will be collected. These field QA blanks will be collected at a rate of 5 percent each of the total samples. In addition, duplicate samples at a rate of 10 percent of the total samples will be collected to monitor the consistency of sampling procedures.

As part of the audit procedures; the Field QA Coordinator will monitor sample collection. A field sampling audit checklist will be completed and a QA field audit report submitted to the Project Manager within 30 days of the QA field audit trip. Any procedures not in compliance with PM RMA USATHAMA and RLSA sampling QC practices will be identified to the Project Manager within 24 hours of observation and proper corrective actions will be taken. Specific QA/QC procedures are discussed in the CMP QA/QC Plan.

Details of the QA program for the field activities to be conducted under this element are detailed in the Monitoring Program QA/QC Plan. As designed, the QA plan will ensure the production of valid and properly formatted documentation of the field procedures.

Field files will be maintained for each site sampled. These files will contain all information pertinent to the collection, custody and shipment of the samples. These files will be reviewed by the Field QA Coordinator within one week of sampling. The CMP Field Procedures Manual for RMA is RLSA's comprehensive procedures document which addresses all of the field requirements. The sampler will be required to follow the procedures, and the Field QA Coordinator will conduct frequent inspections to verify that they are being followed.

7.2.3 Laboratory Analytical Controls

Daily laboratory QC of the analytical systems ensures accurate and reproducible results. Careful calibration and the introduction of control samples (control spikes and blanks) are prerequisites for obtaining accurate and reliable results. Instrumental and sample lot controls are described in the Comprehensive Monitoring Program QA/QC Plan and the approved certified method write-ups.

The Laboratory Coordinator will monitor the analytical controls. Failure to pass the instrumental calibration or control sample QC criteria represents an out-of-control situation. Written notification of the QC failure will be provided to the Project Manager and proper corrective action will be implemented by the Project QA coordinator. Specific discussions of analytical controls are contained in the QA/QC Plan.

7.2.4 Laboratory QA Program

Each laboratory will maintain a chemical data file for each lot of samples analyzed which will include: (1) copies of logsheets of sample receipt; (2) relevant analysts' notebook pages; (3) extraction logsheets; (4) instrumental logsheets; and (5) raw data sheets including complete chromatograms, calibration curve data, calculation worksheets, and final data. Manual QC checks will be performed by the Chemical Analysis Supervisor and the laboratory QA staff in each laboratory as specified in CMP QA Plan.

The Comprehensive Monitoring Program QA Plan details the reviewing and reporting functions of the Project QA Coordinator. A formal review and sign-off sheet will accompany all chemical analysis results for each completed Army lot of samples. It is the responsibility of the laboratory QA staff to check the sign-off sheet periodically to ensure that the review process is complete.

During the active conduct of chemical analyses, the laboratory QA staff will submit a QA Program Status Report upon completion of each analytical lot to PM RMA USATHAMA. This submittal will include a hard copy of the lot QC charts. All points which indicate an out-of-control situation will be evaluated and explained and necessary corrective action to prevent recurrence will be described.

8.0 DATA MANAGEMENT

General data management procedures that apply to all phases of the CMP are addressed in the general Data Management Plan. This section deals with the procedures specific to the management of data generated pursuant to the Ground-Water Monitoring Plan's objectives.

8.1 Analytical Data

Water-quality samples requiring laboratory analysis will be shipped under chain-of-custody to Datachem, Inc., and Enseco-Cal Laboratories. The laboratories will log the samples in a logbook specific to the CMP program and review the sample tags and accompanying field chain-of-custody record for agreement. Any discrepancies will be noted in the logbook and rectified by contacting the Site Manager and/or QA Coordinator upon receipt of the samples. The laboratories will be responsible for assigning the samples to the various analyses as stated on the field chain-of-custody and ensuring that they are conducted within the guidelines of USATHAMA certified methods.

Laboratory personnel will be responsible for the coding of the results of analyses into format prescribed for use in the Installation Restoration Data Management System (IRDMS). Data entry and initial data verification will be conducted by laboratory personnel utilizing the PC-based IRDMS programs provided by USATHAMA. Files will be transferred to the Data Management group in Denver via modem; copies of the data entry coding forms will also be sent for filing in the Denver office. The Data Management group will send these files to the Army's 3Comm network where it will be run through the final data acceptance checks. Acceptable data will be uploaded by the Army's Data Management group into the files serving as the final repository for the data generated under the Rocky Mountain Arsenal IR program. Unacceptable data will be returned to the RLSA Data Management group for correction.

The map records in the IRDMS files for locations of existing stations will be verified by the RLSA team. This information will be provided to the QA Coordinator and used to code map records for entry onto the IRDMS. Data entry and initial data verification will be conducted by the Data Management group. Map data will flow through the IRDMS in the same fashion as described above for the analytical results.

9.0 HEALTH AND SAFETY

9.1 Introduction

The Health and Safety Plan (HASP) for the CMP outlines the necessary information to conduct the ground-water monitoring program in a safe and healthful manner to prevent chemical exposures and employee injuries. The information provided in this section serves only as a supplement to the HASP with information specific to the ground-water monitoring program.

Activities associated with the ground-water program will be performed routinely in Sections 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 19, 22, 23, 24, 25, 26, 27, 28, 30, 31, 32, 33, 34, 35, 36, and off-post. Other sections may be included depending upon remedial activities occurring or an increase in the scope of the program. These sections contain varying degrees of contamination which must be considered. In order to develop the most adequate HASP possible, an evaluation will be made of each sampling and monitoring station, so that specific programs can be developed. Overall procedures and methods are outlined in the following sections.

9.2 Responsibilities

9.2.1 Health and Safety Supervisor (HSS)

The responsibilities of the HSS are the same as in the HASP for the CMP. The HSS will be responsible for advising the ground-water personnel of potential hazards in the areas they will be working in and assigning levels of protection for the associated hazards. The HSS will determine the necessity of health and safety air monitoring during the activities of this program.

9.2.2 Ground-water Monitoring Personnel

The ground-water monitoring personnel will be responsible for coordinating their activities with the HSS. Every week they will be responsible for informing the HSS of their planned activities for the following week.

Personnel will be responsible for reporting any unsafe or potentially hazardous conditions which occur when performing their activities. They will also be familiar with the information instructions and emergency response procedures addressed in the HASP for the CMP. It is also their responsibility to conform to the rules and regulations of the HASP for the CMP.

9.3 Hazard Assessment

Activities associated with the ground-water monitoring program will vary depending upon the type of activity as well as current weather conditions. The sections that pose the greatest risk of potential chemical exposure include Sections 1, 2, 36, and 26. These sections represent the South Plants area (1, 2), Basin A (36), and Basin F (26).

The South Plants area has various chemical hazards present in the soils and ground water that may become airborne and pose an inhalation hazard or a skin absorption hazard. These chemicals include chlorinated pesticides (aldrin, dieldrin), solvents (benzene), and heavy metals (lead, mercury, arsenic). The inhalation route of entry is the greatest hazard on high wind days or very hot summer days. If the weather conditions are present to create an inhalation hazard then respiratory protection will be considered. Normally, however, respiratory protection would not be required.

If the possibility exists for skin contact with contaminated materials (notably water), then chemical protective clothing must be worn which protects against the compounds of concern. More in-depth toxicology on the various chemicals can be found in the HASP for the CMP.

The Basin A area was used as a disposal basin for production operations in South Plants and North Plants. Waste from chemical agent production and pesticide production were disposed in the basin. The basin is dry and unvegetated over much of the area. Even though these unvegetated areas have been covered with dust control suppressant, the main hazard is from inhalation of airborne particulate matter in the basin, which may contain heavy metals (lead, mercury, arsenic) and pesticides (aldrin, dieldrin) and skin contact with contaminated materials (notably water). Invasive activities would also present a potential chemical agent hazard. Ground-water personnel should be familiar with Appendix C of CMP HASP if a chemical agent hazard is present. When working in the Basin A region, Level C or B will be required when airborne dust is likely to be present.

Basin F was a solar evaporation pond used for the disposal of contaminated liquid wastes from chemical operations in the North Plants and the South Plants between 1956 and 1981. However, as a result of the recently completed Basin F Interim Response Action which resulted in the removal of all ponded liquids to temporary storage in three double-walled holding tanks and a covered double-lined holding pond; the temporary placement of accumulated sludges and excavated soils in an enclosed double-lined waste pile, and the covering of the basin floor with a low permeability interim clay cap, the potential exposure hazards presented by this area have been effectively reduced. Health and safety precautions will be taken in this area as the potential exists

for skin contact with contaminated materials such as water. Additional chemical hazards could be encountered during invasive activities. Levels of protection will be determined at the discretion of the Health and Safety Supervisor.

The major hazards associated with the ground-water monitoring activities are likely to be inhalation of vapors and skin and eye contact with contaminated water.

9.4 Personal Protective Equipment

The minimum levels of protection for personnel involved in field activities as part of the ground-water element of the CMP will be as follows:

- Section 36 - field personnel will wear modified Level D protection while performing ground water sampling/monitoring in Section 36.

- Other areas - field personnel will wear Level D protection at all other sampling monitoring sites. Protection will consist of inner and outer rubber gloves, steel toe and shank rubber boots, goggles for eye protection, and cotton overalls. Respirators will be readily available.

All sampling and monitoring efforts will be performed in teams of two. Before commencing activities, field personnel will check in at the safety trailer. While wearing Level D protection, samplers will avoid submerging their hands in water so deeply that water drains into the top of the gloves. Gloves should be taped to the wrists in modified Level D protection. Levels of protection will be upgraded if the Safety Officer deems it necessary.

Respiratory protection may be required in Sections 1, 2, 25, 26, and 36. Full-face air purifying respirators with GMC-H or pesticide cartridges will be used for the majority of work requiring respiratory protection. Work in the area of the Basin F remediation program will require compliance with the applicable HASP. This may require the use of supplied air respirators or self-contained breathing apparatus.

9.5 Decontamination

Decontamination will be required at the end of the work day by all personnel. This includes decontamination and disposal of protective clothing. The personnel will also be required to wash

their hands and face prior to eating, drinking, smoking, or leaving the site. Showers will be mandatory for personnel if working at RMA when Level C or B was required.

Equipment decontamination control will be exercised prior to storing, calibrating, or moving equipment from one section to another. Vehicle decontamination must be performed when driving in Section 36. The vehicles driven in Section 36 must be driven on the service access roads on the perimeter of the section to the decontamination pad in the southeastern corner of Section 36. The vehicles tires, undercarriage, and exterior must be thoroughly steam cleaned at the decontamination pad prior to driving outside of Section 36.

9.6 Emergency Procedures

Personnel will be familiar with the emergency section of the CMP HASP. All injuries, irrespective of seriousness, will be reported to the Health and Safety Supervisor immediately. Any conditions that may create a health or safety hazard will be reported to the Health and Safety Supervisor when they are observed. The Health and Safety Supervisor will then evaluate the condition for corrective action that may be required.

10.0 REFERENCES

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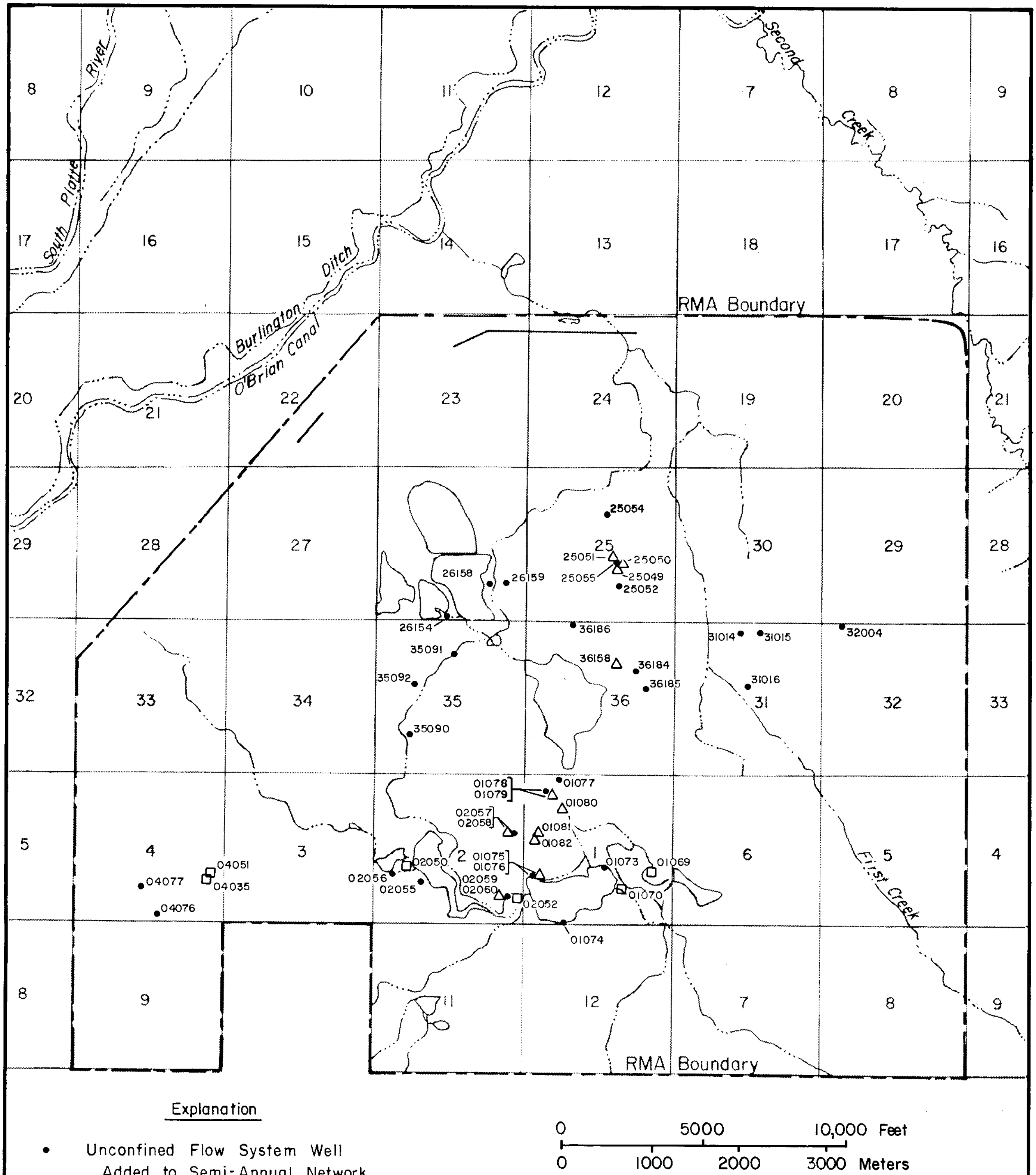
11.0 ADDENDUM

This section details program modifications made to the Spring 1989 semi-annual well sampling network. As indicated in Section 2.3.4 of this Technical Plan, newly installed wells are to be included in the CMP ground-water monitoring network for at least two sampling periods. The network was therefore modified by the addition of 38 monitoring wells recently installed in FY89 (Figure 11-1).

Analytical and hydrologic data obtained from these newly installed wells will allow for greater resolution of contamination migration in the project areas. The majority of the wells are located within cluster sites and provide additional vertical hydraulic gradient information. There is installation procedural documentation on each of these wells, most of which were installed during recent RI/FS programs. There are also comparative RI/FS analytical and hydrologic data available from these sampling sites.

Another modification to the semi-annual monitoring well network is the deletion of six wells from the sampling program. A review of Spring 1988 and previous RI/FS analytical data indicated that information obtained from these six wells (01069, 01070, 02050, 02052, 04035, 04051) was of less relative value as compared to other wells located within project areas. None of the deleted wells occur in cluster sites and none are completed in the Denver Formation. All six of the wells were installed within the last two years under different RI/FS programs. The wells located in Sections 1 and 2 did not significantly add to the current level of understanding as to contamination in the South Plants Project Area. The Section 4 wells were located in an area of otherwise dense well control where the two wells did not significantly enhance the understanding of contamination in the Railroad Classification Yard area.

Another program modification involves the addition of a new analytical laboratory to the group of contractors within the RLSA team. Environmental Science and Engineering, Inc. (ESE) laboratory facilities in Denver will replace Enseco-Cal Lab as the subsidiary CMP analytical laboratory. Analytical parameters will remain consistent with those outlined in Table 3.1-1 and certified reporting limits (CRLs) will be comparable between the primary CMP analytical laboratory, DataChem, Inc., of Salt Lake City and ESE-Denver laboratory.



Explanation

- • Unconfined Flow System Well Added to Semi-Annual Network
- △ Denver Formation Well Added to Semi-Annual Network
- □ Well Deleted from Semi-Annual Network

Prepared for:
U.S. Army Program Manager for Rocky Mountain Arsenal
Commerce City, Colorado

Prepared by:
R.L. Stollar & Associates, Inc.
Harding Lawson Associates

Figure II-1

Semi-Annual Well Network Modifications

12.0 RESPONSES TO COMMENTS ON THE NOVEMBER 1988 CMP DRAFT FINAL TECHNICAL PLAN

Text contained in this section relates responses to comments generated by the Colorado Department of Health (CDH), the EPA, and Shell Oil Company regarding the November 1988 CMP Draft Final Technical Plan. Many of the comments have been addressed as revisions in this May 1989 Final Technical Plan.

Rec'd 4e 1145 1/23/89

STATE OF COLORADO

COLORADO DEPARTMENT OF HEALTH
4210 East 11th Avenue
Denver, Colorado 80220
Phone (303) 320-8333

Roy Romer
Governor

Thomas M. Vernon, M.D.
Executive Director

January 19, 1989

Mr. Donald Campbell
Office of the Program Manager for
Rocky Mountain Arsenal
AMXRM-PM, Bldg 111
Commerce City, CO 80022-2180

Re: State comments on Comprehensive Monitoring Program (Ground Water) Draft Final Technical Plan, November 1988

Dear Mr. Campbell:

Enclosed are the State's comments on the Comprehensive Monitoring Program (Ground Water) Draft Final Technical Plan dated November 1988. A meeting of the MOA parties should be held to discuss this long term monitoring program.

If you have any questions on the attached comments, please contact Mr. Jeff Edson with this division.

Sincerely,

David C. Shelton

David C. Shelton, Director
Hazardous Materials and
Waste Management Division

DS/lh

cc: Michael E. Hope
David L. Anderson
Chris Hahn
Edward J. McGrath
Connally Mears
Michael Gaydosh
Tony Truschel
LTC Scott Isaacson

RMA890890½

RESPONSES TO STATE COMMENTS ON COMPREHENSIVE MONITORING PROGRAM (GROUND WATER) DRAFT FINAL TECHNICAL PLAN

Comment 1. The Comprehensive Monitoring Program (CMP) Technical Plan indicates that future modifications to the program or changes in the monitoring well network will be made by the Army, Shell and their contractors. The State and EPA must be given the opportunity to comment on and/or discuss any proposed changes to this program.

Response: The Colorado Department of Health (CDH) and the EPA will be afforded the opportunity for technical input regarding future modifications of the CMP.

Comment 2. The forthcoming Water Media Report should include information which will be valuable in evaluating the adequacy of the CMP. Therefore, the State may have additional comments after the Water Media Report becomes available.

Response: The State will have the opportunity after having reviewed the Water Media Report to comment on modifications to the CMP.

Comment 3. The Tri-County Health Department is currently conducting a door-to-door survey in the offpost operable unit area. The survey will better define the location of wells, well depth, how the well water is used, and how long people have lived or worked on the property. The findings of this survey will likely increase the number of known wells which are or have the potential to be contaminated from the Rocky Mountain Arsenal. The Army should be prepared to initiate a comprehensive sampling program for those new wells identified as contaminated or potentially contaminated to assess public exposure to RMA contaminants. The results of this sampling program may effect the definition of the extent of contamination in the offpost area and the need may require an expansion of the CMP.

Response: A few of the offpost domestic wells listed in Comment 6 below have been sampled as part of the RMA Offpost RI. Some of these wells have also been sampled under the newer RI/FS tasks. State recommendations resulting from the Tri-County Health Department study will be considered for future CMP well network modifications.

Comments 4. The CMP should be expanded to include long term on and offpost surface water monitoring in addition to the long term ground water monitoring program. On page

60 the plan states that future contamination assessments will include, at a minimum, "ground-water/surface-water interactions". The Army has previously concluded that ground water discharges to First Creek during periods of low flow are the primary contaminant pathways to off-post surface water. Recently discovered surface seeps along First Creek have been found to be contaminated. Unless the Army intends to issue a "Surface Water CMP Technical Plan," a long term surface water monitoring program, similar in structure to those included in Tasks 4, 44, and 39, should be incorporated into the Ground Water CMP Technical Plan.

Response: Ground water is one of four elements comprising the CMP. The other elements include surface water, air, and biota. A separate technical plan has been prepared for each of these elements.

Comment 5. Pg. 6, Section 1.2 - Objective 3 states that the CMP will "maintain specific area ground-water monitoring program for regulatory data base maintenance". The meaning of this statement needs to be clarified.

Response: The cleanup and remediation of contamination at Rocky Mountain Arsenal is being conducted pursuant to the Comprehensive Environmental Response and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA). CERCLA requires that remedial actions attain applicable or relevant and appropriate substantive federal and state standards. Insofar as interim response actions, e.g. the Basin IRA, are implemented as part of the process of remediation, CERCLA provides that these actions shall, to maximum extent practicable, attain applicable or relevant and appropriate federal and state standards.

Comment 6. Pg. 22-23, Section 2.0 - The design and the objectives of the CMP must be expanded to include the monitoring of domestic wells which are known to be or have the potential to be contaminated from the Rocky Mountain Arsenal. At a minimum semi-annual tap samples should be taken from the locations specified below. Additionally, the CMP should attempt to identify other potentially impacted domestic wells for incorporation into the monitoring program. The samples should be analyzed for all parameters included on Table 3.1-1.

M. Dorthy Lambert, 11921 E. 96th Ave, Commerce City, Colorado, 80022, High potential for contamination.

Mike Collins, 11515 E. 96th Ave, Commerce City, Colorado, 80022, High potential for contamination.

Al Ohle, 11841 E. 96th Ave., Commerce City, Colorado, 80022, High potential for contamination.

Tom Smalldone, 9610 Peoria, Commerce City, Colorado, 80022, High potential for contamination.

Burney Thomas, 10720 Brighton Road, Henderson, Colorado 80640; Alluvial aquifer/ domestic well, DIMP detected at 500 ppb on 1/25/85.

Alex Muniz, 11997 Brighton Road, Henderson, Colorado 80640; Alluvial aquifer/domestic well, DIMP detected at 22 ppb on 1/28/85.

Robert Abel, 11810 Brighton Road, Henderson, Colorado 80640; Alluvial aquifer/domestic well, DIMP detected at 190 ppb on 1/28/85.

May Bishop, 12375 Brighton Road, P.O. Box 1, Henderson, Colorado 80640; Alluvial aquifer/ domestic well, DIMP detected at 6.5 ppb on 1/14/85.

W.R. Koger, 12460 Tucson, Henderson, Colorado 80640; Alluvial aquifer/domestic well, DIMP detected at 3.4 ppb on 1/8/85.

Gene Y. Saka, 10690 E. 120th Avenue, Henderson, Colorado 80640; alluvial aquifer/ domestic well, DIMP detected at 21 ppb on 1/28/85.

Mrs. Wilhelm, 11670 Brighton Road, Henderson, Colorado 80640; Alluvial aquifer/ irrigation well, DIMP detected at 900 ppb and Chloroform detected at 7 ppb on 1/15/85.

John Yellenick, 9982 E. 112th Avenue, Henderson, Colorado 80640; Alluvial aquifer/ irrigation well, DIMP detected at 420 ppb on 1/23/85.

Norvil Daniels, 11620 E. 120th Avenue, Henderson, Colorado 80640; Alluvial aquifer/ domestic well, DIMP detected at 15 ppb on 1/9/85.

DM and H Cattle, Attn: Harold Blitt, 11010 Peoria, Henderson, Colorado 80640; Alluvial aquifer/livestock well, DIMP detected at 340 ppb, Endrin detected at 0.3 ppb, and TCE detected at 1 ppb on 1/15/85.

Response: See response to Comment 3.

Comment 7. Pgs. 24-27, Section 2.1.1.2 - The State recommends that the following two additional areas be included in the area-specific monitoring program;

a. South Plants/Section 35 Area: Contaminants migrate from the South Plants (Section 2) through Section 35, NW Section 34, and Section 27. This area can be given a "tentative" designation (similar to the North Plants) until a more detailed characterization is presented in the Water Media Report.

b. Eastern Tier/Sections 31 and 32 Area: This is an area suspected of low level contamination associated with the toxic storage yards and burn pits. This area, also, can be labeled "tentative" until the more detailed characterization (task 23 Source Monitoring Wells; Water Media Report) is completed.

Response: The Army also recognized that additional monitoring was necessary in these areas. Three new wells have been installed in the South Plants/Section 35 area and four wells in the Eastern Tier/Section 31 and 32 area. Further annual monitoring in these areas will be contingent upon the review of analytical data from these wells. As clean up projects may be identified for the two areas outlines, the requirement for semi-annual monitoring of these specific-areas would be incorporated into the CMP.

Comment 8. Pg. 27, Section 2.1.2 and Pg. 37, Section 2.3.3 - There are an insufficient number of Alluvial aquifer monitoring wells northwest of the Northwest Boundary Containment System ("NWBCS") to define the extent of shallow groundwater contamination. It is impossible to detect contaminants northwest of the Burlington Ditch with the present monitoring system. Sections 15 and 16 only contain monitoring wells at coarse density along there north and south section lines. Additional monitoring wells are needed in Section 15 and 16 to correct this problem.

Contaminants such as chloroform and DIMP have been detected historically in the area northwest of the Northwest Boundary Containment System (offpost Sections 9 and 10) with the aid of consumptive use wells. The northwest plume is a significant pathway that must be fully defined and monitored. Once improved, the monitoring program in this area will be valuable in determining the extent of shallow aquifer contamination and monitoring the temporal changes in plume characteristics due to the NWBCS and dilution resulting from the Burlington Ditch and O'Brian Canal.

Response: All available offpost monitoring wells located downgradient (northwest) of the NWBCS are currently included in the CMP monitoring network. Increased monitoring well density in this area would necessitate the installation of new wells. If such a modification is made in the future, CDH will be provided an opportunity for additional technical input. Based on the Tri-County assessment of offpost wells that may be utilized in defining the extent of contamination northwest of the NWBCS, additional wells may be selected for incorporation into the CMP.

Consideration will be given to the installation of additional wells in this area if the need arises.

Comment 9. Pg. 27, Section 2.1.3 - The water-level monitoring network for the Denver Formation should be designed to monitor individual Denver Formation sandstone units to enable the assessment of ground water flow paths through these units.

Response: The water-level monitoring network of the CMP is designed to assess Denver Formation zones by monitoring individual sandstone units. Preparation of Denver Formation zone potentiometric surface maps will be based on these hydrologic data.

Comment 10. PP. 28 and 29, Section 2.2 - The monitoring network(s) should not include wells which have been designated "unacceptable" pursuant to the Task 44 well construction evaluation. Wells of unacceptable construction include 23095, 23108, 26006, 26015, 26017, 26020 and 27016. "Unacceptable" wells must be replaced with new wells of acceptable construction.

Response: The wells listed above are included in the CMP for the purposes of maintaining sample location continuity. These wells would be considered as candidates for replacement under the CMP.

Comment 11. Pg. 31, Section 2.2.3 - To be effective, the Denver Formation monitoring network must assess changes in rate and extent of contamination via horizontal and vertical flow paths. Historical Army programs (Task 4, Task 44, and the 360 degree monitoring programs) did not follow this methodology, opting for point by point monitoring or discrete depth monitoring independent of hydrogeology.

The present CMP for the Denver Formation is focusing on contaminant pathway monitoring with such efforts as identification of key aquifer zones and evaluation of the vertical head and contaminant distributions at well clusters. The Water Media Report should include a three-dimensional analysis of contaminant migration in the Denver Formation. The CMP will likely require modification to monitor individual Denver Formation sandstone units identified in the Water Media Report.

Response: The CMP Denver Formation monitoring network is directed toward providing data that will facilitate a three-dimensional assessment of changes in the rate and extent of contamination. These assessments will necessarily be based on the current level

of hydrogeologic understanding as presented in the WRIR. Refinements to the WRIR level of understanding will be made on the basis of additional data generated under the CMP.

Comment 12. Pgs. 33-51, Section 2.3 - The State recommends that the following additional wells be added to the network to enhance coverage in specific areas.

A. Alluvial Aquifer Monitoring Network

Section	Monitoring Well	Purpose/Location
2	02014	enhanced coverage, west portion
23	23039	plume definition, west side
	23058	plume definition, west side
	EP-06	proposed well, upgrade priority
24	24158	plume definition, east side
	EP-14	proposed well, upgrade priority
	EP-16	proposed well, upgrade priority
25	25011	enhanced coverage, east portion
	25015	enhanced coverage, north portion
	25018	enhanced coverage, north portion
27	27051	enhanced coverage, SE corner
34	34504	enhanced coverage, SE corner

The perimeter monitoring wells in Section 25 listed above (monitored under Task 44) were replaced by the recent Task 42 wells. The Task 42 wells are appropriate. However, the Task 44 wells will also enhance coverage in the north and east parts of Section 25.

B. Denver Formation Monitoring Network

Section	Monitoring Well	Purpose/Location
02	02018	enhanced coverage, west portion
24	24159	plume definition, east side
35	35056	enhanced coverage, central portion
36	36056	plume definition, Basin A east
	36090	plume definition, Basin A west

Response: The CMP Technical Plan has been modified to include additional monitoring wells in the areas noted. Several of the specific wells listed above have been included. In some cases, alternative wells have been selected.

Comment 13. Pgs. 46-51 and Plates 2.3-1 and 2.3-2 - All additional wells to be included in the program should be added to the appropriate lists and Plates. Well 24136 is missing from Plate 2.3-2. Well 26061 is included on Plate 2.3-2 but not on one of the lists.

Response: The Draft Final CMP Technical Plan, Plates 2.3-1 and 2.3-2 present wells that comprise the annual monitoring-well network. The wells mentioned in the Plates for the semi-annual or quarterly monitoring-well networks were not included in this plan. Modifications to any of the monitoring networks will be reflected in revised lists and Plates. The errors identified have been noted.

Comment 14. Pgs 52-54, Section 3.0 - In addition to the parameters listed in Table 3.1-1, water samples should be analyzed for caprolactum, bisphthalate, and dichlorobenzene. The list of parameters to be analyzed should also be expanded to include any and all nontarget analytes which are frequently occurring at elevated levels.

Response: The CMP analytical parameters list is designed to be flexible. Results from the CMP QA/QC program and the CMP GC/MS analyses will be used to refine the list of target analytes and nontarget analytes frequently detected at elevated levels.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION VIII
999 18th STREET - SUITE 500
DENVER, COLORADO 80202-2405

Ref: 8HWM-SR

JAN 11 1989

Mr. Donald L. Campbell,
Deputy Program Manager
Office of the Program Manager
Rocky Mountain Arsenal
ATTN: AMXRM-TO
Commerce City, Colorado 80022-2180

Re: Rocky Mountain Arsenal, (RMA),
Comprehensive Monitoring Program,
Draft Final Technical Plan,
November 1988.

Dear Mr. Campbell:

We have reviewed the above referenced document and have the enclosed comments. Please call me at (303) 293-1528, if there are questions on this matter.

Sincerely yours,

Henry C. Schroeder for

Connally Mears
EPA Coordinator
for Rocky Mountain Arsenal Cleanup

Enclosure

cc: Thomas P. Looby, CDH
David Shelton, CDH
Patricia Bohm, CAGO
Lt. Col. Scott P. Isaacson
Chris Hahn, Shell Oil Company
R. D. Lundahl, Shell Oil Company
David Anderson, Department of Justice
Preston Chiaro, EBASCO

RECEIVED

JAN ?? 1989

RESPONSES TO EPA COMMENTS ON THE CMP
DRAFT FINAL TECHNICAL PLAN

Comment 1: Have the paleochannel locations been reevaluated?

Response: The paleochannel locations were evaluated in the RMA Water Remedial Investigation (RI).

Comment 2: Page 14, second bullet, page 27, last line, and page 31, third bullet, this should read "degree of hydraulic connection between water bearing units", not aquifer units.

Response: The text will be revised to read "water bearing" units instead of "aquifer" units.

Comment 3: Has the small component of flow from the alluvium to the Denver formation been measured?

Response: The potential for interaction of the unconfined flow system with the Denver Formation is discussed in the Water RI. The discussion in the Water RI is based on vertical hydraulic gradient measurements. Quantitative components of flow have not been measured.

Comment 4: What is the lithology of the upper Denver beneath the RMA? There is no discussion of this.

Response: The Denver Formation lithologies vary considerably beneath RMA. Generally, the Denver Formation lithologies beneath RMA include lignites, lignitic shales, claystones, shales, organic shales, volcaniclastics, silty sandstones, and sandstones. Depending on depth and location, these various lithologies may or may not be indurated, well cemented, or deeply weathered.

Comment 5: Figure 1.3-4, put in parenthesis by Buffer Zone claysone or siltsone. This will clarify what comprises the buffer zone.

Response: Figure 1.3-4 will be revised to indicate that the Buffer Zone is claystone or siltstone.

Comment 6: How many Denver wells are located in areas of unsaturated alluvium?

Response: Due to fluctuations in the extent of the unsaturated alluvium, the number of Denver wells located in these areas varies.

Comment 7: On the list of new wells (alluvium and Tkd), no wells are listed for Sections 28 and 22 (for alluvium) and no wells in Section 28 for the Denver Formation. Please explain.

Response: New Denver Formation wells have not been installed in Section 28, and no new alluvial wells have been installed in Sections 22 and 28.

Comment 8: Not all Denver formation wells listed in Table 2.3-4, show up on Plate 2.3-2. Well 37390 is not shown.

Response: The wells presented on Plates 2.3-1 and 2.3-2 correspond to the wells listed in Table 2.4-1. These wells comprise the CMP annual sampling event. Wells sampled semi-annually and quarterly are included within the annual well network.

Wells monitored for water level only are not shown on either of the plates.

Comment 9: Can EPA receive the annual reports?

Response: Annual reports will be provided to the EPA.

Comment 10: Is the claystone in the upper Denver monitored? If not, EPA feels it should be. The monitoring program should include the drilling of monitoring points capable of detecting and evaluating contaminant movement in the upper Denver claystone itself. The monitoring holes should be drilled such that permeability of only the upper claystone can be determined. Monitoring for quality should be at least once per year. At least one well upgradient and one well downgradient of each of the three containment systems should be completed.

Response: Ground water representative of the formation flows in the upper Denver Formation is monitored at RMA both upgradient and downgradient of the containment systems.

Comment 11: Table 3.1-1, Analytical Parameters. Vinyl chloride should be included as a target analyte in the volatile organohalogens because it is a potential breakdown product of tetrachloroethylene.

Response: Vinyl chloride as a nontarget compound would be considered for inclusion in the list of CMP analytical parameters.

Comment 12: Proposed Monitoring Wells/Locations. Consideration should be given to including the following wells or locations in the program. These may involve installation of new wells in some locations where suitable monitoring wells are not available.

a. EPA has recommended on several occasions that wells be installed and monitored in the eastern portion of Section 36 in order to evaluate the plume emanating toward the northeast from Basin A. Proposed EBASCO wells 34 and 35 (Rocky Mountain Arsenal Proposed Monitoring Wells, September 27, 1988, handout received at a Task 23 meeting) would fill this gap in the program if suitable wells do not exist in this area.

b. Additional wells are still recommended to be monitored between the North and Northwest Boundary Containment Systems. Denver wells should be monitored between wells 22079 and 23229, and also between wells 22027 and 22079. Both Denver and alluvial wells should be monitored off-post between the systems.

A new off-post Denver cluster well should be drilled south of the O'Brian Canal, the NW 1/4 of the SE 1/4 of the SE 1/4 of Section 15 provide a more reliable picture of ground water flow and potential contaminant movement. This site should individually monitor the top three sand units in the Denver formation. These wells are needed to allow a more complete picture of the relationship of the hydraulic gradient in the Denver formation in this area to be developed.

Three new off-post Denver cluster pair site wells are needed along the upper west of the Arsenal to enable off-post ground water flow associated with the Northwest and Irondale systems to be adequately characterized. One well pair should be located in the NW 1/4 of the SE 1/4 of the NW 1/4 of Section 22. The second well pair should be located in the NW 1/4 of the SE 1/4 of the SE 1/4 of Section 21. The third monitoring site should be located in the NW 1/4 of the SE 1/4 of the SE 1/4 of Section 29.

c. An off-post alluvial well should be monitored between wells 37334 and 37331 downgradient of the Northwest Boundary Containment System.

d. Alluvial and Denver well clusters should be monitored at each end of the North Boundary Containment System.

e. At least one alluvial well should be monitored west of the North Boundary Containment System (between wells 23150 and 22007).

f. Additional wells are needed downgradient and off-post from ICS in Section 28. An alluvial well should be monitored between wells 28027 and 28023 (between the Northwest and Irondale systems). Off-post alluvial wells should also be monitored in the Irondale area, specifically between wells 37358 and 37334 and in the paleochannel trending northwest from Section 33 to Section 32.

g. A well located in the paleochannel which trends north from North Plants should be monitored to evaluate migration from the North Plants area. Proposed EBASCO well 28 would fill this gap in the program if a suitable monitoring well is not available in this area.

h. Although North Plants is designated as specific area to be monitored on page 27, specific Denver wells were not selected to be monitored in the North Plants area (pages 34-35), and no new Denver wells are being installed in Section 25 (Table 2.3-2). EPA feels strongly that source-specific monitoring of the Denver Formation in North Plants (especially where the alluvium is unsaturated) should be implemented. EBASCO has proposed three new Denver wells in North Plants to specifically evaluate contamination from the tank farm, the 1727 sump, and buildings 1506 and 1501. These wells should be included in the CMP if other suitable Denver wells are not available.

<u>Response</u>: Consideration will be given to the recommendations for additional wells or locations in future CMP monitoring or well installation programs.

Shell Oil Company

One Shell Plaza
P.O. Box 4320
Houston, Texas 77210

January 6, 1989

Mr. Donald L. Campbell
Office of the Program Manager
Rocky Mountain Arsenal, Building 111
ATTN: AMXRM-PM
Commerce City, CO 80022-2180

Re: United States v. Shell Oil

Dear Mr. Campbell:

Enclosed herewith are Shell Oil's comments on the "Comprehensive Monitoring Program Draft Final Technical Plan, November 1988 - Groundwater."

Sincerely,

R. D. Lundahl
Manager Technical
Denver Site Project

RDL/jy

Enc.

RESPONSE TO SHELL OIL COMPANY COMMENTS ON THE NOVEMBER 1988 CMP DRAFT FINAL TECHNICAL PLAN

GENERAL COMMENTS

The primary objectives stated for the Comprehensive Monitoring Program (CMP) are to maintain a groundwater quality database, assess changes in the rate and extent of contamination, and to verify groundwater plume configuration. Comparison of plume maps from 1975-1982 data, Task 4 (1985-1986), and the Water RI (1987) clearly show that plume configurations on a regional scale have not changed significantly in the past ten years. Consequently, it is unnecessary and wasteful of resources to sample wells even as frequently as annually. With possible rare exceptions, the objectives of the CMP involve the monitoring of long-term ground-water trends, not requiring, at least, semi-annual and quarterly sampling.

Response to General Comments

One of the primary objectives of the CMP is to maintain a regulatory database. The quarterly monitoring program is directed toward compliance with substantive regulatory requirements. Another CMP objective is to provide data for system design, construction and operational purposes. Recent modifications to the NBCS are changing the hydrologic regime near the north boundary and thus warrant more frequent monitoring.

The comparison of plume maps from 1975 to the present shows that plume configurations on a regional scale have changed significantly, based on the wells sampled to characterize the plume. The addition of new wells to the monitoring program has significantly increased the level of understanding regarding the areal and vertical extent of contamination.

SPECIFIC COMMENTS:

Comment 1. Page 1, fifth paragraph

In the first line for accuracy, replace industrial with chemical.

Response: For accuracy, "chemical" will be used.

Comment 2. Page 3, first full sentence

Two disparate facts are connected in that the DBCP associated with rail shipments has not been detected offpost since about 1985. The reference is more appropriately connected with the DBCP off the north boundary of the RMA.

Response: The sentence will be revised to read as follows: "Since 1978, dibromochloropropane (DBCP), a nematocide shipped from RMA by rail from 1970 to 1975, has been detected in offpost ground water. Offpost DBCP contamination of ground water still persists north of RMA."

Figure 1.1-2

For consistency with the second full paragraph on page 3, solid waste disposal areas and the chemical sewer system should be shown in Figure 1.1-2.

Response: Figure 1.1-2 will be revised accordingly.

Comment 3. Page 11, fourth paragraph

The range of hydraulic conductivity of alluvial aquifer stated differs from that in the Preliminary Water RI.

Response: The hydraulic conductivity (K) values cited in the CMP Draft Final Technical Plan range from 2.1×10^{-1} to 2.1×10^{-4} feet per second (ft/sec), and May 1982 is the reference. The K values cited in Version 1.2 (January 1989) of the Water RI Report range from 172.8 ft/day (2.0×10^{-3} ft/sec) to 2551 ft/day (2.9×10^{-2} ft/sec). Best estimate K values in Table 2.4-4 of the report range from 1×10^{-2} to 7×10^{-4} ft/sec, using a conversion factor of 86,4000 sec/day. The May 1982 figures have a higher K value at the upper end of the range but are otherwise in general

agreement with K values used in the Water RI Report.

Comment 4. Figure 1.1-3

Composite contaminant distribution is generalized to the point of being possibly misleading. For example, the figure suggests that all contaminant plumes in the Western Tier converge at the Irondale Containment System which is in fact not the case.

Response: All contaminant plumes in the RMA Western Tier do not converge at the ICS. The figure will be revised accordingly.

Comment 5. Page 14, second paragraph

The range of hydraulic conductivities of the Denver Formation differs from that given in the Water RI.

Response: The range of Denver Formation K values cited in the CMP Draft Final Technical Plan is 10^{-4} to 10^{-6} ft/sec for sand units and 10^{-8} ft/sec for claystones (May 1982). The range of K values used in the Water RI Report is such that the standard deviation of the logs for the sample population is nearly one order of magnitude. Given this wide range of values, 67 percent of the Denver Formation K values would lie within the range of 4.4×10^{-5} to 4.3×10^{-7} ft/sec. The values used in the CMP Technical Plan are thus in general agreement with those presented in the Water RI.

Comment 6. Page 19, first full paragraph

In the third sentence it should be stated that the pilot NBCS was activated in 1978 and the present (expanded) NBCS was activated in 1981. The Irondale Boundary System was activated in late 1981.

Response: The sentences in question will be revised to read as follows: "The pilot NBCS, activated in 1978 and expanded in 1981, and the NWBCS, activated in 1984, are operated by the Army. The ICS, activated in 1981, is operated by SCC on the western border of RMA and forms a hydraulic barrier to offpost contamination transport."

Comment 7. Page 22, third paragraph

While Shell participated in the first several working meetings on the initial design of the CMP it did not concur in objectives selected by the Army. Shell believed that the CMP should have more utilitarian value and provide the framework under which groundwater sampling in support of remedial studies should be conducted, not simply verification of plumes that have been verified repeatedly since the late 1970s.

Response: Because significant plume changes have occurred since the late 1970s and continue to occur as a result of clean up activities and natural migration changes, the objectives of the CMP are to maintain and update the understanding of ground water hydrology and contaminant migration mechanisms. We believe the CMP provides the framework to support the design and construction of interim and final clean up actions in addition to the operation of clean up systems and the implementation of clean up actions. The CMP provides a basis upon which the long term effectiveness of the clean up program can be evaluated.

Comment 8. Page 23, first bullet

It is not possible to meet this objective unless centroids of plumes are monitored. The monitoring well selection method used is specifically biased towards choosing wells on the perimeter of the plumes (as a RCRA detection monitoring program would be), not in the centroids of the plumes (as an assessment program should be).

Response: A significant amount of information from previous studies was available to guide design of the CMP monitoring network. The water-quality monitoring philosophy was developed from evaluations of contaminant distributions, source area locations, and remedial facility locations. Monitoring wells, which were selected on the basis of previous results, are located both in plume centroids and near plume margins. The areal and vertical extent of contamination and the distribution of contaminant patterns cannot be assessed by monitoring plume centroids alone. Additional monitoring wells have been incorporated into the monitoring networks to assume that the objectives stated can be adequately supported.

Comment 9. Page 24, second complete paragraph

Sampling on a semi-annual basis in specific areas is not justified. Sampling should be conducted on an annual basis at most.

Response: Consideration is being given to the modification of the semi-annual monitoring network. Network modifications will be based on the short-term and long-term data requirements to support the objections of the CMP.

Comment 10. Page 26, Item 5

Only 3 wells are proximal to the Basin A Neck Area. It is doubtful that these wells will provide useful information for the Basin A Neck IRA or future remedial actions.

Response: The following alluvial wells (shown in Plate 2.3-1) are included within the CMP annual sampling network and are located in the Basin A Neck area: 36123, 36177, 36145, 36137, 35020, 35061, 35077, 35065, 35079, and 35018. Also, Plate 2.3-2 of the CMP Technical Plan shows 21 Denver Formation monitoring wells located in the Basin A Neck area. Additional monitoring requirements necessary to support the

Basin A Neck IRA or future remedial actions must be identified for incorporation into the CMP. In the event technical data is collected in a program other than the CMP, at a minimum, this data must be provided to the CMP assessment.

Comment 11. Page 26, Item 6

The proposed network for the South Plants does not cover any of the main plumes in that area. As proposed it will neither verify plume configurations nor provide useful information to assess plume configurations or remedial alternatives.

Response: The CMP monitoring-well network for the South Plants addresses the need for long-term monitoring in that area. The CMP monitoring well network in the South Plants does not adequately support the short-term data requirements necessary to develop detailed plume configurations or support remedial clean up programs. Additional monitoring requirements necessary to support these assessments and programs must be identified for incorporation into the CMP. In the near-term the South Plants monitoring-well network may be modified on the basis of results obtained from Shell's investigation and the CMP.

Comment 12. Page 27, Item 8

It is doubtful that eight wells over one square mile will provide useful information in the Basin A area.

Response: Table 2.4-1 of the CMP Draft Final Technical Plan indicates that 15 alluvial wells and 19 Denver Formation wells are to be sampled in Section 36 during the CMP annual monitoring event. The need for more detailed monitoring of all or portions of Section 36 will be based on the technical data requirements of a remedial action.

Comment 13. Page 27, first complete paragraph

In the last sentence, the offpost network is effectively the same as that used for the offpost RI monitoring network. It is doubtful that the CMP network will provide useful data above what has already been collected by the RI.

Response: The utility of the data collected under the CMP is determined by the technical requirements of the monitoring program. THe technical requirements are based upon the objectives of the offpost monitoring conducted as part of the CMP is viewed as essential to the short-term and long-term objectives of the clean up program.

Comment 14. Page 27, last paragraph

The last sentence should be deleted. It is hypothetical and may place more emphasis on vertical flow components than is technically justified.

Response: The vertical flow component between Denver Formation water-bearing units is not a hypothetical phenomenon, as demonstrated by vertical hydraulic gradients measured at well clusters. Assessments of ground-water flow paths are integral to an evaluation of the vertical extent of contamination. We have therefore removed the last sentence as requested.

Comment 15. Page 29, first full paragraph

In what program will the closure of inadequate monitoring wells be done?

Response: The program for these well closures is Interim Response Action 3 (IRA-3), the Abandoned Well Closure Program.

Comment 16. Page 34, first paragraph

There should be sound technical reasoning for including any wells that have previously not had detectable concentrations of contaminants in them (i.e., there is no reason to monitor wells "where contamination has not been detected" without specific reasons for expecting contaminants to occur).

Response: There is sound technical justification for sampling wells that historically have not contained detectable contaminant concentrations. Part of this justification involves monitoring upgradient water-quality conditions to evaluate background water-quality and to assess previously undetected contaminant migration.

Comment 17. Page 45, third paragraph

It is doubtful given the present hydrologic regime that Basin F needs to be sampled quarterly or even semi-annually.

Response: Basin F is sampled quarterly in order to comply with substantive regulatory requirements and to provide data in support of the ongoing remedial actions there. The hydrodynamic response to Basin F remediation warrants close monitoring.

Comment 18. Page 60, second bullet

A stratigraphic/hydrogeologic evaluation was conducted in the Water RI. Another one will only be useful if a significant number of new wells is installed to provide additional data. It is doubtful that this is desired or relevant to the objectives of this program.

Response: Part of the CMP strategy involves sampling all newly installed wells. Stratigraphic/hydrogeologic evaluations of the alluvium and Denver Formation will utilize data from these new wells and will expand where possible the level of current understanding presented in the Water RI Report.

Comment 19. Page 60, first complete paragraph

A comprehensive assessment of contamination was supposed to be conducted for the Water RI. Why do it again? Is it suggested that it was not complete or that it needs to be done every year?

Response: An annual comprehensive contamination assessment is within the scope of the CMP. This assessment is directed toward evaluating source/plume relationships, contaminant migration pathways, and movement and extent of contamination at RMA with respect to the clean up program activities. The language was not intended to suggest shortcomings with the Water RI; the CMP objective is to collect and evaluate data that postdate the Water RI effort.

Comment 20. Page 65, top of page

What and where is the "Data Management Plan"? Who is the "Data Management Group"? (third paragraph, same page).

Response: The data management plan outlines the general data management procedures that the RLSA team will follow during the Comprehensive Monitoring Program (CMP). Each element has differing data requirements and procedures for manipulating these data which are presented in the plan. The RLSA team is in the process of developing this plan.

The data management group is a team of computer experts from Ebasco Services, Inc. under the direction of Dan Golden.

Comment 21. Page 67, fourth paragraph

Basin A also received waste from the North Plants.

Response: The first sentence of the fourth paragraph will be revised to reflect the fact that Basin A received wastes from both South Plants and North Plants.